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THE INDIAN JOURNAL OF ENTOMOLOGY

Notice to Contributors

1. Papers for publication in the Journal should be sent to the Chief Editor by name. Papers from non-members are accepted if they are communicated by an Ordinary or Honorary member of the Entomological Society of India.

2. Authors should suitably indicate, either at the beginning or at the end of their papers, the institution or the laboratory where their work on which the paper is based was carried out.

3. Every paper should be accompanied by an abstract and should usually end with a summary, giving the principal points discussed in the paper or important conclusions arising therefrom.

4. Literature should be cited in the text by giving the name of the author(s) and year of publication in parenthesis, or where the name of the author(s) occurs in the sentence, by giving the year only. It should be listed at the end of the paper in the alphabetical order of authors' names, followed by the year, name of the Journal (underlined and abbreviated according to the latest edition of the World List of Scientific Periodicals), volume number (doubly underlined), part of the volume if necessary (in brackets) and page reference. Example : Hardy, J. E., 1939, *Bull. ent. Res.*, **30** (2) : 237-246. An exception may be made in the case of taxonomic papers and "Short Notes", wherein references may be given as footnotes or in the text, but they must be in the same style as described above.

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8. Names of orders, superfamilies and families of insects, wherever occurring, must be commenced with a capital letter. Common English names of insects should be commenced with a small letter, e.g., pink bollworm, codling moth, etc.

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The
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Vol. II. Part 1. June 1940.

DESCRIPTIONS OF SOME NEW SPECIES OF *EMPOASCA* WALSH (EUPTERYGIDÆ, JASSOIDEA) FROM NORTH INDIA

By HEM SINGH PRUTHI,
Imperial Entomologist, New Delhi.

Empoasca devastans Distant is very common on cotton in India and does considerable damage by desapping the leaves. Some other species of *Empoasca* also occur on this crop.

The Cotton Botanist, Punjab, Lyallpur, in connection with his work on the behaviour of different varieties of cotton in reference to the attack by Jassids had a collection of this group made and submitted the same to the writer for determination. During the last few years, the staff of the Entomological Section of the Imperial Agricultural Research Institute has also collected a large number of jassid species from several food-plants at Delhi. These collections as well as those received from the Assistant Entomologist, Sind, Sakrand, and Supdt., Potato Station, I.A.R.I., Simla have yielded several new species which are described below. All the type specimens are deposited in the Imperial Pusa Collection, Laboratory of the Imperial Entomologist, New Delhi. My thanks are due to Mr. Mohd. Afzal, Cotton Botanist, Punjab, and other workers who have given me an opportunity of examining their collections.

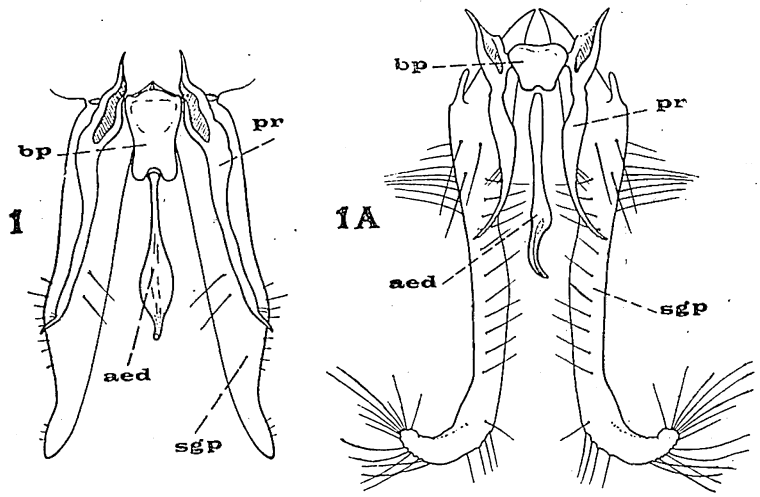
Empoasca solanifolia, sp. nov.

Female.—Large, about 4 mm. long, robust, pale brown (Pl. I, figs. 1 and 1A). Vertex flat, slightly raised, gradually continuous with face without any intervening sharp margins. Eyes prominent; ocelli distinct but of the same colour. Face longer than broad (4 : 3); clypeus long, slightly expanded near apex; genæ very narrow. Pronotum over one and a half times longer than vertex, flat, transparent. Scutellum about as long as pronotum, deeply transversely impressed in middle, with a pair of brown stripes in the anterior half; tip yellow. Elytra about

twice as long as abdomen, transparent. Veins thin but distinct. Abdomen tinged with yellow. Ovipositor stout, marked with black at the tip; pygopher covered with a few minute hairs.

Male.—Slightly smaller but of the same colouration as the female.

Male genitalia (Text-fig. 1).—Sub-genital plates long, narrow especially in the distal region. Parameres elongated and narrow, pointed at the apices. Basal plate flat, rectangular. Aedeagus very narrow in the basal region, very much swollen in the distal half but again pointed at the apex, round the gonopore. The genitalia on the whole are of the same general appearance as those in *Empoasca devastans* Dist. (Text-fig. 1A).



TEXT-FIGS. 1 and 1A. Male genitalia of *E. solanifolia* (1), and of *E. devastans* (1A); highly magnified.
(*aed*, aedeagus; *bp*, basal plate; *pr*, parameres; *sgp*, sub-genital plates.)

Holotype & Allotype.—A female and a male specimens respectively collected on potato plants at Simla by Pushkar Nath in August, 1938; (I. P. C.* Nos. R/7829 and R/7830).

Paratypes.—Several specimens of both sexes collected along with the type specimens.

In the Imperial Pusa Collection there is a specimen of this species from Nepal (7,000 ft.) collected by Col. Bailey in July, 1937.

Remarks.—Along with the specimens described above, one male and one female specimens were obtained, which are much smaller but otherwise resemble the typical specimens of this species. In some specimens there are irregular yellow markings on vertex, scutellum, etc.

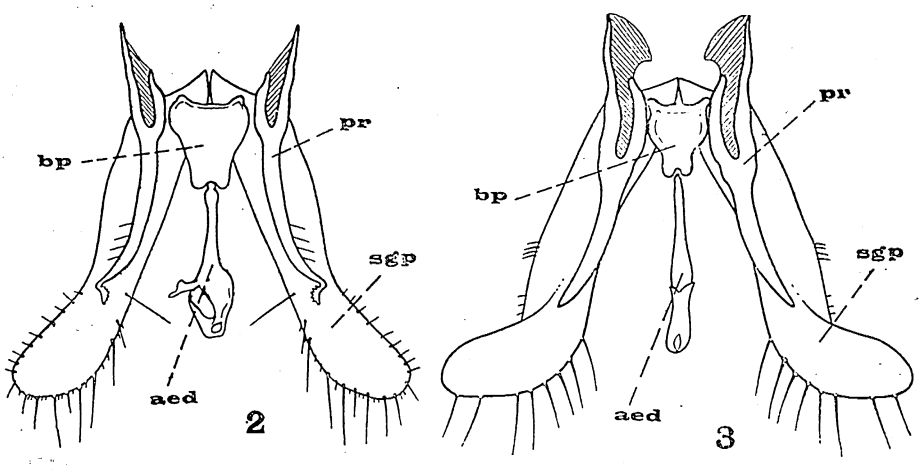
* The Imperial Pusa Collection is referred to as I. P. C. for the sake of brevity.

Empoasca minor, sp. nov.

Female.—Small, 2.75 mm. in length (Pl. I, figs. 2 and 2A). Shining green. Head large; vertex about 0.5 mm. long, flat, yellowish-green, with a pale stripe at the tip and a pair of large grey discal spots, which are sometimes faint; margins not sharp, in line with the outer margins of the eyes. Ocelli nearer the eyes, dark, fairly distinct. Eyes large, greyish. Face about 1.0 mm. long and 0.6 mm. broad, with a light broad stripe along the median line; genæ narrow. Pronotum slightly shorter (0.4 mm.) than the vertex, flat; anterior margin rounded, posterior margin slightly concave, yellowish. Scutellum slightly longer than pronotum, yellowish, with a dark narrow stripe on each side of the median line; tip green. Elytra much longer than the body, transparent, greenish; apical region dark grey. Legs green, especially in the tarsal region; pulvillus black. Abdomen distinctly yellow, with the posterior segments and ovipositor green. Pygopher covered with numerous pale hairs.

Male.—Resembles female, except that it is slightly smaller and the discal spots on its vertex are not very distinct.

Male genitalia (Text-fig. 2).—Sub-genital plates large, fairly broad, expanded in the apical region where there are numerous stiff hairs on the margins. Parameres long, narrow, sharply bent and dented at the apices. Basal plate large and flattened. Aedeagus rod-like in the proximal two-third, globular and expanded in the distal region.



TEXT-FIGS. 2 and 3. Male genitalia of *E. minor* (2), and of *E. binotata* (3), highly magnified. Letterings as in Text-fig. 1.

Holotype and Allotype.—A female and a male specimens respectively collected on grape vine at Lyallpur by M. Abbas on 26. vi. 1939; (I. P. C. Nos. R/7840 and R/7841).

Paratype.—Two female specimens collected from the same locality and food-plant as the types on 26. vi. 1939.

The species is also found on *falsa* and cotton at Lyallpur.

Empoasca binotata, sp. nov.

Female.—Shining green, old specimens yellow, about 3.0 mm. in length (Pl. I, figs. 3 and 3A). Vertex 2.5 mm. long, almost as long as broad between eyes, somewhat raised, slightly produced at the yellowish apex, longitudinally sulcate, yellowish-green with a pair of deep green spots in the anterior region ; margins of vertex not sharp. Eyes conspicuous, margined with green. Ocelli large, grey, situated near the eyes. Face only slightly longer than broad (9 : 8) ; clypeus green. Pronotum as long as the vertex, pale green, with whitish patches near the anterior margin. Scutellum prominent, longer than vertex, pale green, with a pair of pale brown blotches near the basal angles. Elytra much longer than the body, shining green, almost opaque in the region of clavus, transparent and grey in the distal region. Veins distinct, sometimes marked with green, especially along the costa and claval margins. Legs and abdomen as in *E. minor*, described above.

Male.—Slightly smaller than the female, but with the pronotum proportionately bigger, which is longer than the vertex (Pl. I, fig. 3B).

Male genitalia (Text-fig. 3).—Sub-genital plates long, flap-like, especially expanded in the apical region where there are strong and long marginal hairs. Parameres large, stout, pointed at the apices. Aedeagus long, gradually widening in the distal region to a blunt apex.

Holotype and Allotype.—A female and a male specimens respectively collected on lucerne by M. Abbas at Lyallpur on 26. vi. 1939 ; (I. P. C. Nos. R/7849 and R/7850).

Paratype.—A female specimen collected along with the holotype.

Distribution and food-plants.—*E. binotata* has also been collected on artichoke, brinjal and *bhindi* at Lyallpur during April-June and at Delhi on cucurbits in April and on lucerne, *Cajanus cajan*, cowpea, berseem, mustard, etc., in September-December, 1939.

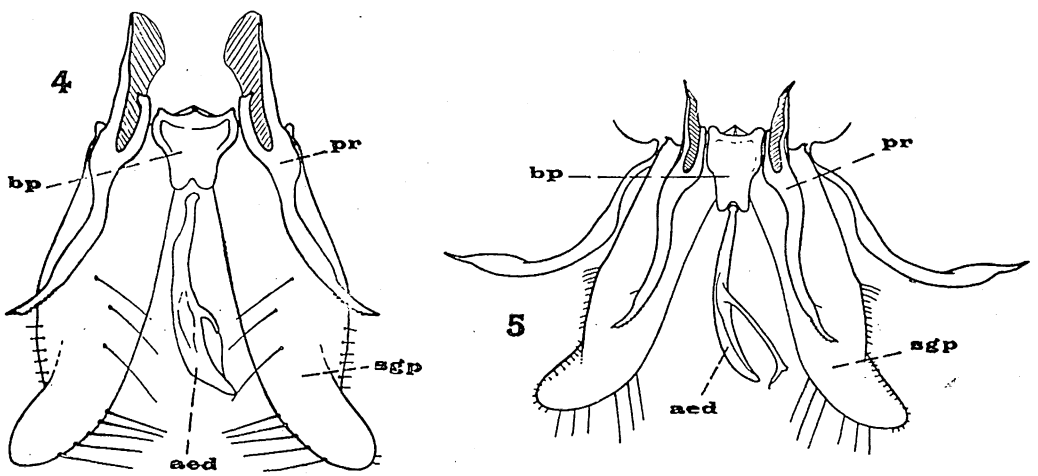
Remarks.—This species can be distinguished from *E. minor* by its size and by the size and colouration of the distal spots at the vertex, as well as the colouration of the elytra. The apical region of the vertex varies in shape from being broadly rounded to pointed.

Empoasca punjabensis, sp. nov.

Female.—Small, 3.3 mm. long, green or yellowish-green (Pl. I, figs. 4 and 4A). Vertex flat, smooth, distinctly medially sulcate, almost pointed

at the apex, green with a pair of deep green minute spots in the anterior region (sometimes indistinct or absent). Eyes elongated, sometimes margined with green ; ocelli about midway between the apex and eyes, small, dark grey. Face almost as long as broad. Pronotum longer than vertex, transparent, concave at the posterior margin. Elytra longer than the body, transparent, greenish-yellow (costal margin deep green) in the proximal two-thirds, clear and dirty white in the distal region. Scutellum with a medial dark-grey broad stripe. Legs pale yellow, marked with deep-green patches on tarsi ; pulvillus black. Abdomen yellow, ovipositor stout, green, especially in distal region.

Male.—Vertex (Pl. I, fig. 4B) slightly shorter (0.25 mm.) than in the female (0.35 mm.) and less pointed, almost rounded at the apex.



TEXT-FIGS. 4 and 5. Male genitalia of *E. punjabensis* (4), and of *E. tabaci* (5). Letterings as in Text-fig. 1.

Male genitalia (Text-fig. 4).—Sub-genital plates large, flattened and expanded, slightly narrow in the apical region. Parameres large, narrow, pointed and dentate at the apices. Aedeagus long, narrow in the proximal region, wide in the distal half.

Holotype and Allotype.—A female and a male specimens respectively collected on berseem at Delhi by Ram Saran on 18. iii. 1938 ; (I. P. C. Nos. R/7891 and R/7892).

Paratypes.—A few specimens of both sexes collected at Delhi and Lyallpur from several food-plants during the same season as the type specimens.

Distribution and food-plants.—This species seems to be widely distributed in North India and has several food-plants. It has been obtained from zinnias, tobacco, beans, cotton, guava, etc., at Lyallpur during June,

1939 and on lucerne, tobacco, safflower, *bajra*, potato, carrot, tomato, brinjal, and lentil at Delhi during February-May, 1938.

Remarks.—*E. punjabensis* can be readily distinguished from *E. binotata* by the flat and pointed vertex and the structure of the male genitalia. In some specimens collected from tobacco, safflower and potato, the spots on the vertex are very indistinct or even absent.

Empoasca tabaci, sp. nov.

Female.—Of about the same size (3.3 mm.) and shape as *E. punjabensis*, but distinctly yellow in colour (Pl. II, figs. 5 and 5A). Vertex flat, slightly raised, sulcate at base, almost pointed at the apex, yellow, with a pair of large grey spots in the anterior region. Eyes grey, diffused with yellow; ocelli near the eyes, pale and rather indistinct. Face somewhat longer than broad. Pronotum about one and a half times as long as vertex, almost straight at the posterior margin, yellow, marked with pale patches in the anterior region. Scutellum pale, with a pair of large orange-coloured spots near the basal angles. Elytra about one and a half times longer than abdomen, yellow and sub-transparent in the proximal two-thirds, almost clear in the distal region. Vein distinct. Abdomen including the genital segments pale yellow, deep yellow above.

Male.—Vertex shorter and less pointed at apex than in the female (Pl. II, fig. 5B).

Male genitalia (Text-fig. 5).—Almost similar to those of *E. punjabensis*, but the sub-genital plates are less flattened and basal plate is more elongated. Aedeagus gradually widens in the posterior region.

Holotype and Allotype.—A female and a male specimens respectively collected on tobacco at Delhi by Sher Khan on 4. v. 1938; (I. P. C. Nos. R/7932-33).

Paratypes.—Several specimens collected along with the types.

The Imperial Pusa Collection also contains a number of specimens collected by T. Ahmad on tobacco on 21. iv. 1938 and one specimen (pale green in colour) collected by Pushkar Nath at Simla in August, 1938.

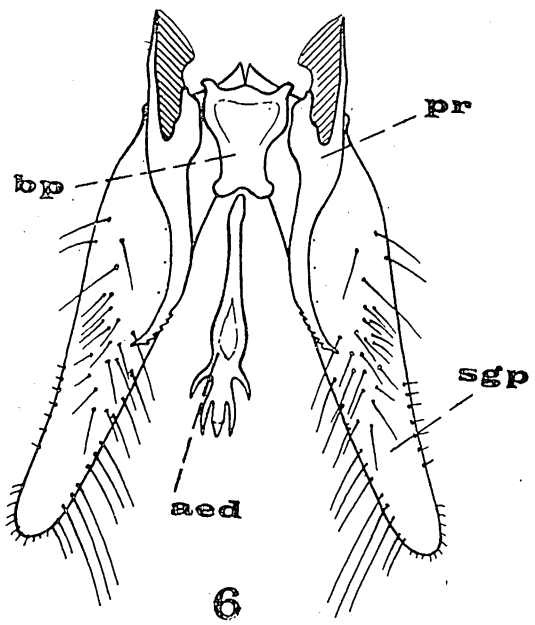
Remarks.—This species is closely allied to *E. punjabensis* from which it chiefly differs in general colouration.

Empoasca parathea, sp. nov.

Male.—Large (3.25 mm.), green, elongated in appearance (Pl. II, figs. 6 and 6A). Vertex shorter than broad between the eyes, deeply sulcate in proximal region, slightly raised, almost pointed at the apex, yellowish-green, distinctly yellow at apex, with a pair of ill-defined minute grey spots in depressions about middle. Eyes dark-grey, suffused with green; ocelli nearer eyes, surrounded by green, large and distinct. Face longer than

broad ; frons yellow, especially in the superior region, lower part marked with green in lateral regions ; clypeus green.

Pronotum longer than vertex (4 : 3), green, with whitish patches near the anterior margin which is rounded. Scutellum yellowish-green, with a rectangular grey patch on the disc, transversely depressed in middle. Elytra long, pale green, shining and transparent ; veins thin but distinct. Legs pale yellow but marked with green in the distal region ; pulvillus black. Abdomen greenish-yellow beneath, deep yellow on the dorsal side, genital segments greenish.



TEXT-FIG. 6. Male genitalia of *E. parathea*. Letterings as in Text-fig. 1.

Male genitalia (Text-fig. 6).—Sub-genital plates elongated, comparatively broad in the proximal region, gradually narrowing and tapering in the distal, with numerous hairs all over. Parameres comparatively small and slender, dentate and pointed at the apices. Basal plates narrower and constructed in the distal region. Aedeagus long, narrow in the proximal half, wide in the distal region, produced into two pairs of processes near gonopore.

Female.—Similar to the male except that it is larger (3.50 mm.) and its thorax is much longer than vertex (Pl. II, fig. 6B) and the posterior abdominal segments are distinctly green.

Holotype and Allotype.—A male and a female specimens respectively collected by H. L. Bhatia on soybean leaves at Delhi on 1. xi. 1938 ; (I. P. C. Nos. R/7949-50).

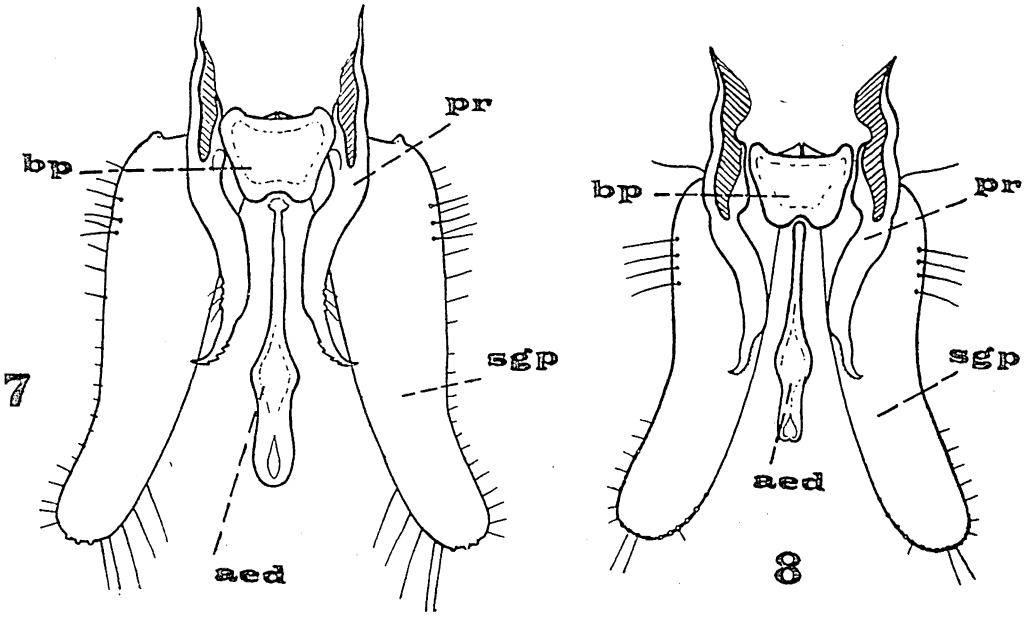
Paratypes.—Several specimens of both sexes collected along with the type specimens at Delhi.

Distribution and food-plants.—This species has been also collected on brinjal at Delhi and on castor at Lyallpur.

Remarks.—*E. Parathea* is allied to *E. punjabensis*, described on a previous page. From the latter it can be distinguished by the size, colour of vertex and markings thereon, long face and the structure of the genitalia. *E. thea* Dist. comes close to these two species, but Distant's description is so vague that it is difficult to place his species exactly.

Empoasca kerri, sp. nov.

Female.—Small, about 3.0 mm. in length, greenish-yellow or yellow (Pl. II, figs. 7 and 7A). Vertex short, flat or slightly raised, broadly



TEXT-FIGS. 7 and 8. Male genitalia of *E. kerri* (7), and of *E. kerri* var. *motti* (8). Letterings as in Text- fig. 1.

rounded at apex, yellow, with irregular grey markings in anterior region which are absent in some specimens. Eyes dark purple; ocelli large, pale green, conspicuous. Face slightly longer than broad, yellow. Pronotum about double the length of vertex; the anterior margin rounded, the posterior concave. Scutellum about as long as the pronotum, yellow except in middle where it has a pale longitudinal patch. Elytra long, transparent, pale yellow. Legs pale green; pulvillus black. Abdomen orange yellow, genital segments green.

Male.—Slightly smaller than the female. Vertex more rounded at the anterior margin (Pl. II, fig. 7B).

Male genitalia (Text-fig. 7).—Sub-genital plates flattened, gradually narrowing in the distal region. Parameres comparatively small, narrow and serrated in the distal region, apices pointed. Basal plate squarish, flat. Aedeagus very narrow and rod-like in the proximal half, bulbous in middle, expanded at apex.

Holotype and Allotype.—A female and a male specimens respectively collected by W. Kerr at light at Delhi on 9.xi.1939. (I. P. C. Nos. R/7970-71).

Paratypes.—A large number of specimens of both sexes collected along with the type specimens.

Distribution and food-plants.—This species has also been obtained at Delhi from castor (September, 1939), *guara* (August, 1939) and maize (September, 1939).

Empoasca kerri, var. **motti,** nov.

This form (Pl. II, figs. 8 and 8A) differs from the form *E. kerri* in colouration and in general build of the body. It looks more robust, though about similar in length.

Male and Female.—Yellowish-green. Vertex smaller than pronotum (3 : 4), almost flat, greenish-yellow, distinctly yellow at apex. Eyes almost black. Pronotum smooth, flat. Scutellum green, medially broadly pale especially near tip, dark near the basal angles. Tegmina long, narrow, semi-transparent, pale green, deep green at the costal and claval margins, grey in the distal region.

Male genitalia (Text-fig. 8).—Similar to those in *E. kerri.* Sub-genital plates flattened, curved, of almost uniform width throughout.

Holotype and Allotype.—A female and male specimens respectively collected by P. Mohan from potato on 11. i. 1939 at Lyallpur ; (I. P. C. Nos. R/8004-5).

Distribution and food-plants.—This variety seems to be common in North India. I have specimens before me collected from linseed, cowpea, *mung*, castor and cotton at Lyallpur, from *guara* and cotton in Sind and from potato at Delhi.

(*Received for publication on* 30. iii. 40).

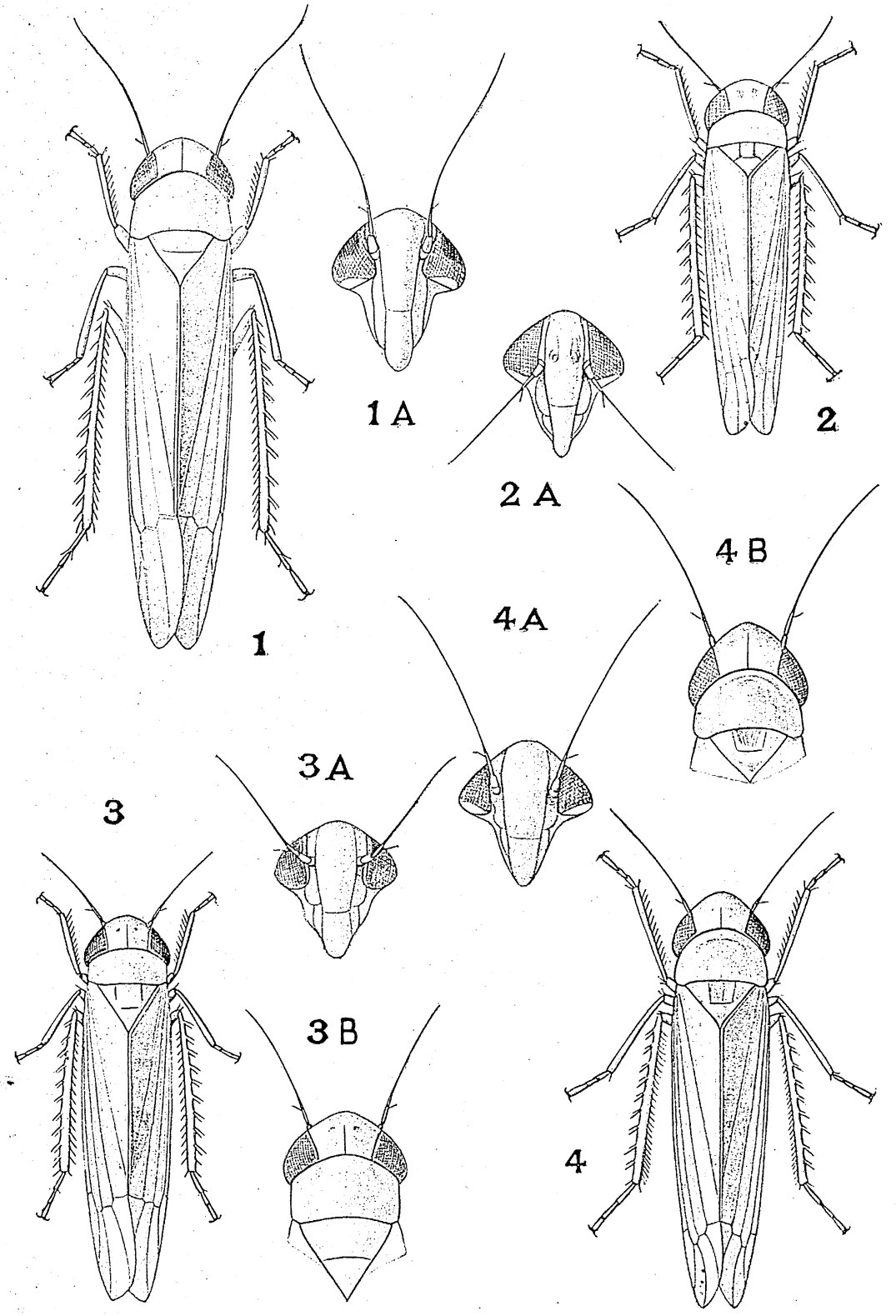
Explanation of Plates I & II.

Plate I.

Fig. 1. *Empoasca solanifolia*, sp. nov., female; dorsal view; × 14.
Fig. 1A. *Empoasca solanifolia*, sp. nov., female, face; × 18.
Fig. 2. *Empoasca minor*, sp. nov., female; dorsal view; × 14.
Fig. 2A. *Empoasca minor* sp. nov., female, face; × 18.
Fig. 3. *Empoasca binotata*, sp. nov., female; dorsal view; × 14.
Fig. 3A. *Empoasca binotata*, sp. nov., female, face; × 18.
Fig. 3B. *Empoasca binotata*, sp. nov., male, face; × 18.
Fig. 4. *Empoasca punjabensis*, sp. nov., female; dorsal view; × 14.
Fig. 4A. *Empoasca punjabensis*, sp. nov., female, face; × 18.
Fig. 4B. *Empoasca punjabensis*, sp. nov., male, face; × 18.

Plate II.

Fig. 5. *Empoasca tabaci*, sp. nov. female; dorsal view; × 14.
Fig. 5A. *Empoasca tabaci*, sp. nov., female, face; × 18.
Fig. 5B. *Empoasca tabaci*, sp. nov., male, face; × 18.
Fig. 6. *Empoasca parathea*, sp. nov., male; dorsal view; × 14.
Fig. 6A. *Empoasca parathea* sp. nov., male, face; × 18.
Fig. 6B. *Empoasca parathea* sp. nov., female, face; × 18.
Fig. 7. *Empoasca kerri*, sp. nov., female; dorsal view; × 14.
Fig. 7A. *Empoasca kerri*, sp. nov., female, face; × 18.
Fig. 7B. *Empoasca kerri*, sp. nov., male, face; × 18.
Fig. 8. *Empoasca kerri*, var. *motti*, nov., female; dorsal view; × 14.
Fig. 8A. *Empoasca kerri*, var. *motti*, nov., female, face; × 18.



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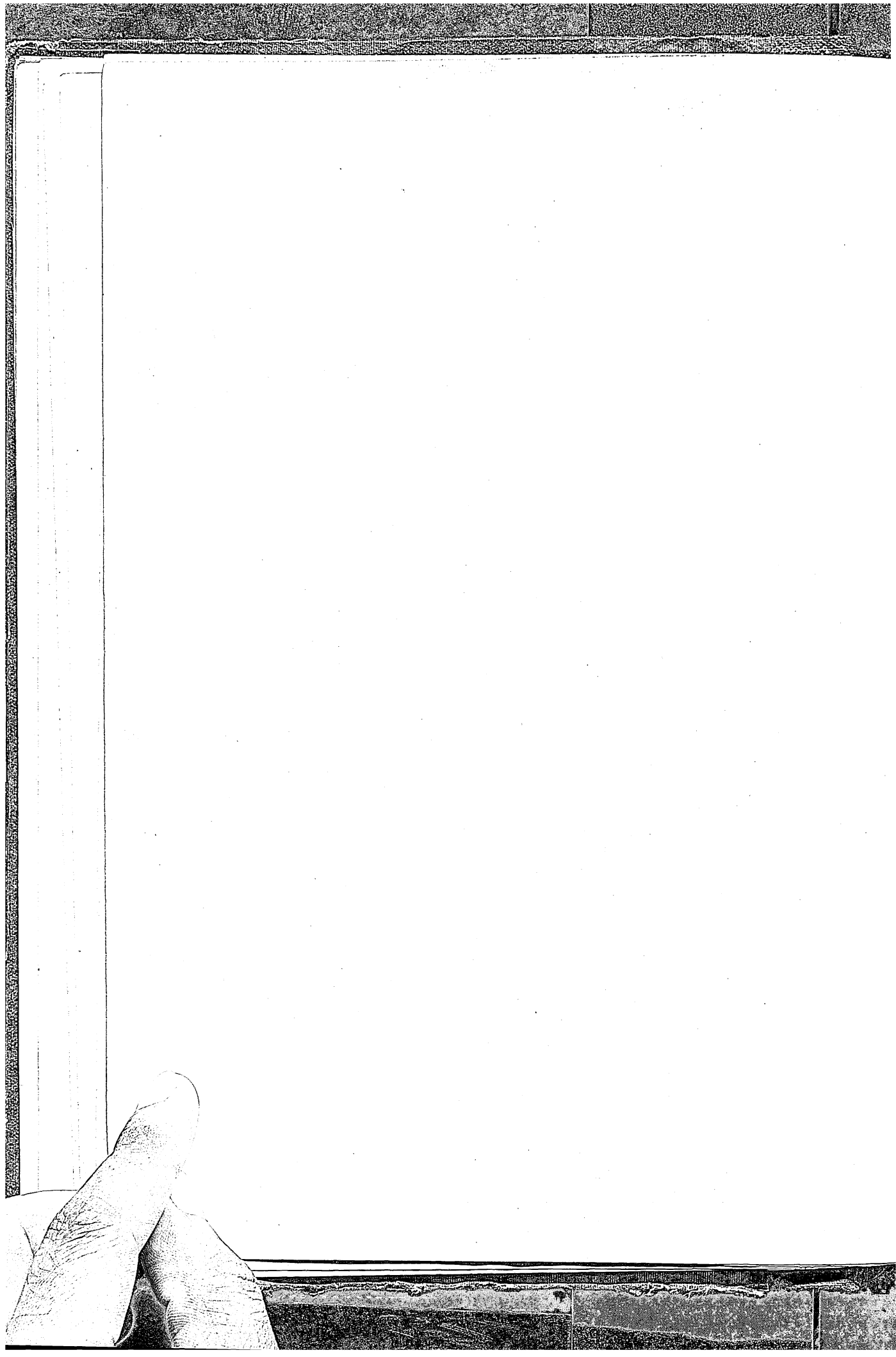

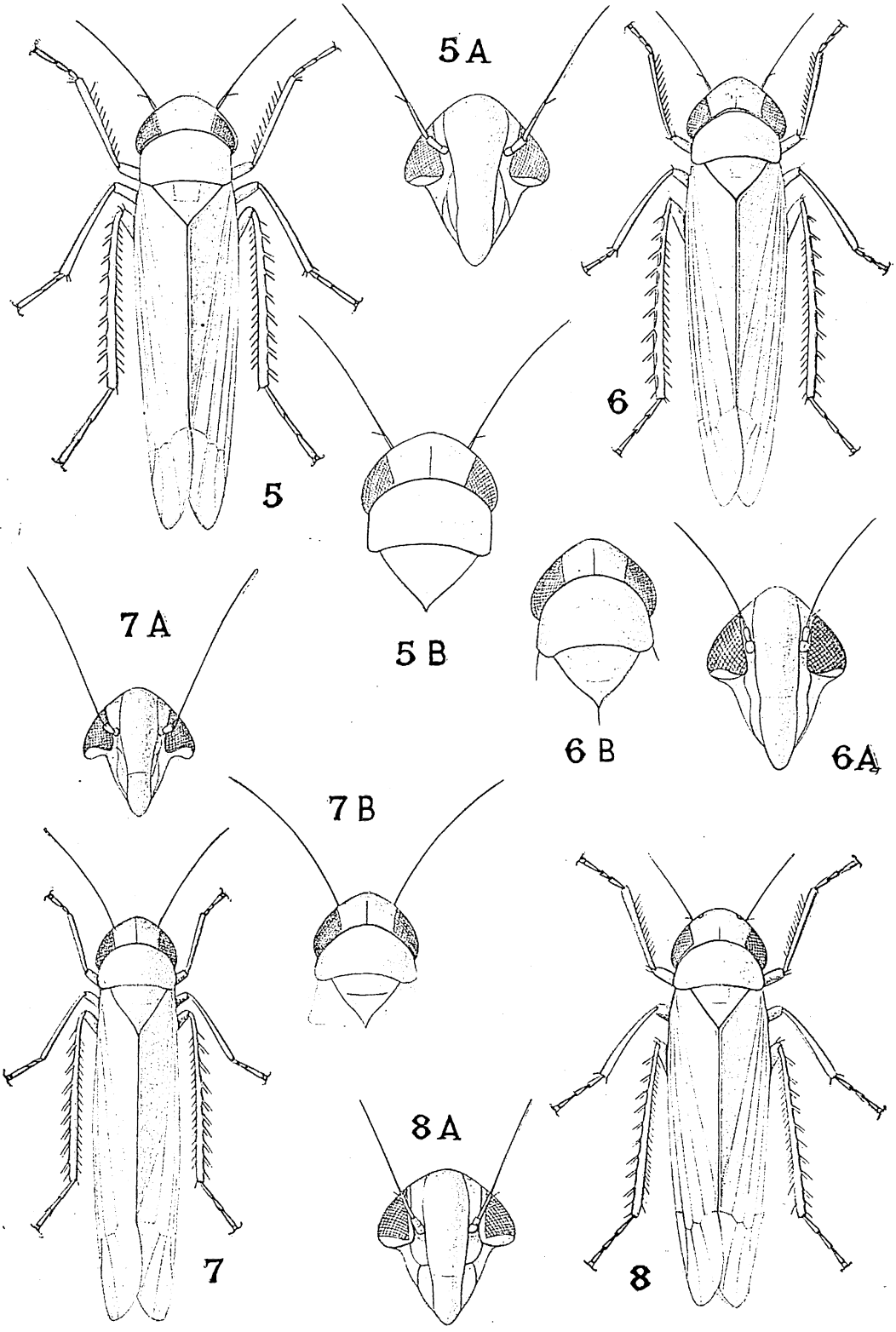

INDIAN JASSOIDEA

A NEW INDIAN PLUME-MOTH (ALUCITIDÆ, LEPID.)

By T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.R.E.S., F.Z.S.,
Rodborough Fort, Stroud (England)

Platyptilia superscandens, n. sp.

Male.—26 mm. expanse.

Head pale ferruginous-brown ; frontal tuft rather roughly scaled, slightly shorter than diameter of eye ; *antenna* slender, about 2/5 of fore-wing, pale fuscous spotted with darker ; *labial palpus* porrect, dull ferruginous-brown, second segment rough-scaled above, as long as diameter of eye, its apex slightly exceeding frontal tuft, third segment less than half of second, rather slender and acuminate, slightly down-curved towards its apex, which is whitish.

Thorax pale ferruginous-brown with considerable whitish admixture ; metathorax white : *foreleg* ferruginous-brown, tibia lined exteriorly with white, its apical fourth slightly dilated with scales and with a well-developed strigil projecting beyond these scales ; tarsus, first and second segments whitish exteriorly, first to third segments with whitish basal rings : *midleg* dull ferruginous-brown, lined with white on tibia and tarsus, tibia very slightly expanded at apex, which emits a pair of short blunt spurs, of which the outer is about 3/4 of inner : *hindleg* slender, dull ferruginous-brown, tibia rather darker at 2/3 and at apex, proximal spurs from about 2/3, outer spur about 2/3 of inner, spurs rather blunt-tipped, distal spurs from apex, rather stout, blunt-tipped, outer spur about 2/3 of inner, which is slightly longer than third tarsal segment : tarsus, first segment paler basally, blackish-fuscous on posterior 3/5, second and third segments whitish, narrowly blackish-fuscous apically, fourth segment mostly dark, fifth segment wholly blackish : *forewing* broad, cleft from 3/4 : first segment broad, apex very slightly projecting, its termen slightly concave and oblique, lower angle obtuse ; second segment as broad as first, its upper angle slightly rounded, its termen very slightly crenulate, tornus well-marked : dull ferruginous-brown : a well-marked equilateral costal triangle, its basal half dark brown, its apical half blackish, its apex extending to below base of cleft, its inner side almost straight, its outer side slightly concave and well removed from base of cleft, its outer basal corner slightly beyond base of cleft; costal edge between base of wing and triangle blackish sparsely irrorated with white scales, a longitudinal patch of dark brown scaling beneath costa at 1/3 of wing ; discoidal area coarsely overlaid with whitish scales and a few similar whitish scales along dorsal area, both segments lightly irrorated whitish and with a broad pale

ill-defined line before and parallel to termen. Cilia on costa from base to praeterminal line blackish brown, narrowly cut with whitish beyond costal triangle, from praeterminal line to apex fuscous, a slight blackish wisp at apex, on termen whitish with strong black basal scales which are continued within cleft as far as praeterminal line, otherwise within cleft whitish, on dorsum whitish with a moderate black scale-tuft at 2/3 and a smaller one at 5/6 (below base of cleft), a few smaller scattered black basal scales throughout, and blackish from 1/2 of second segment to tornus : *hindwing* cleft from about 2/5 and 1/6, first segment spatulate, evenly enlarged posteriorly, apex rounded ; second segment elongate-triangular, its tip acute, termen straight, oblique ; third segment moderately broad, its tip obtuse, tornus evident at 1/2 ; ferruginous-fuscous : Cilia fuscous, rather darker at tips of first and second segments ; on dorsum of third segment whitish at bases especially on either side of a moderate flat black basal scale-tooth commencing at tornus, with a few scattered black club-scales between base of wing and tornus and a few scattered black hair-scales between scale-tooth and tip of segment.

Abdomen slender, basal segment white, other segments dark ferruginous-brown, segments 1-3 with some white and reddish scaling tending to form indistinct oblique lateral stripes and similar scaling (less distinct) on sides of following segments.

Near *P. exaltata* Zeller, 1867, which is smaller (18-22 mm.), face with only a short conical scale-projection.

Holotype.—Male (Fletcher Colln. No. 10237) from Kashmir, Killanmarg (about 11,000 feet), 29.vii.1931, taken by me on a ridge above the alpine meadows, a restricted locality which also produced *Platyptilia isocrates*, *P. sedata* and *P. semnocharis*, all described and only known from this ridge. This specimen was sent to the late Mr. Meyrick for description as new but he misidentified it (*Exot. Microlep.*, IV, 1932, **12** : 334) as *P. exaltata* Zeller, and redescribed as *dejecta* the true *exaltata*, of which I have examined Zeller's Type in the British Museum. Only one example could be found and the species was perhaps just appearing, but this was my last visit to Killanmarg. It is not evident why Mr. Meyrick recorded *P. sedata* (*loc.cit.*) as found in August ; actually, the single example was taken by me on 15th July, 1931 and I could find no more on subsequent visits on 18th, 26th, 27th, 28th and 29th July.

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STUDIES ON INDIAN APHIDIDÆ

I.—THE APHID FAUNA OF DELHI

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INTRODUCTION

The Aphididæ or plant-lice are serious pests of field crops and fruit trees in India and other parts of the world. Furthermore it has been established that a large number of aphids are transmitters of numerous plant-virus diseases. The species, *Myzus persicæ* (Sulz.), for instance, is known to be associated with no less than twenty-one such diseases (Smith, 1937).

The aphids have been extensively studied in Europe, America, Japan and Java; in India, however, very little attention has been paid to them. The only worker who has done some work seriously on the systematics and biology of these insects in India was Das (1918). The other workers, who have paid some attention to different aspects of the Indian Aphididæ, are Deshpande (1937) from Poona, George (1927) from South India (Coimbatore) and Krishnamurti (1928, 1930) from Mysore (Bangalore). During the past two years the author has been making a survey of the Aphididæ found in Delhi and its environs. As a result of this study, about twenty species, belonging to eight genera, have been identified, and some of these species are well known crop pests in India and abroad. Notes on their chief diagnostic characters, biology and ecology are given in the following pages.

No sexual forms in the case of any species have so far been observed in the Delhi area, reproduction being entirely by parthenogenesis. They multiply generation after generation asexually and are most abundant during spring and early summer, but gradually disappear later, due partly to predaceous and parasitic enemies and chiefly on account of excessive heat of the summer. Some of the species have adapted themselves remarkably to this climate; they continue to breed on certain plants in sheltered places even during the hottest months, *viz.*, May and June. *Aphis gossypii* Glov., *A. maidis* Fitch and *A. laburni* Kalten. are, for example, met with practically throughout the year.

Some of the species found in the Delhi Province also occur in Great Britain and their descriptions are given in Theobald's well known publications (1926, 1927 and 1929).

I take this opportunity of recording my grateful thanks to Dr. Hem Singh Pruthi, Imperial Entomologist, for facilities for work, constant

encouragement, guidance and criticism. My thanks are also due to my colleague, Mr. M. S. Mani, for going through the manuscript and making some useful suggestions.

Aphis Linnaeus

1758. *Aphis*, Linnaeus, *Syst. Nat.*, (ed. 10), **1** : 451.

Genotype.—*Aphis sambuci* Linnaeus

Head without any prominent frontal tubercles; antennæ six-segmented, sensoria round. Cornicles cylindrical or slightly tapering; cauda usually shorter than cornicles, rather elongated or subconical; mostly constricted near the middle. Wings usually normal.

The following species of this genus occur in Delhi:— *Aphis gossypii* Glover, *A. maidis* Fitch, *A. laburni* Kaltenbach, *A. rumicis* Linnaeus, *A. sacchari* Zehntner, *A. nerii* Fonscolombe.

Key to the species from Delhi

1.	General colour distinctly yellow or almond-yellow	2.
	General colour green or black.....	3.
2.	Body deep yellow; cornicles, cauda and anal plate black; 9-12 sensoria in a line on third antennal segment.....	*A. nerii*
	Body light or almond-yellow; cornicles, cauda and anal plate brown; 8-12 sensoria not in a line on third antennal segment.....	*A. sacchari*
3.	General colour yellowish to dark green.....	4.
	General colour very dark green or black.....	5.
4.	Body elongate oval; cornicles small, slightly swollen near the middle; 15-18 sensoria on third, 4-5 on fourth and 1-2 on fifth antennal segments	*A. maidis*
	Body normal; cornicles long, cylindrical; 5-8 sensoria on third antennal segment only	*A. gossypii*
5.	Dark green; 11-20 scattered sensoria on third and 1-5 on fourth antennal segments.....	*A. rumicis*
	Shiny-black; 3-6 sensoria in a line on third antennal segment only.....	*A. laburni*

Aphis gossypii Glover

(Fig. 9)

1854. *Aphis gossypii*, Glover, *Patent office Rep., Washington*, 62.
1855. *Aphis malvae*, Koch, *Die Pflanzenlause* (*Aphiden*), 125.
1877. *Aphis cucurbiti*, Buckton, *Monogr. Brit. Aphid.*, **2** : 56.
1882. *Aphis citrulli*, Ashmead, *Florida Despatch*, **1** : 241.
1883. *Aphis cucumeris*, Forbes, *Rep. Nox. Ben. Ins. Illinois*, **12** : 83-91.
1915. *Aphis parvus*, Theobald, *Bull. ent. Res.*, **6** : 127.

1917. *Aphis teclonae*, Van der Goot, *Faun. Ind.-Nederland*, **1** : 3, III.
1918. *Aphis malvacearum*, Van der Goot, *Mem. Indian Mus.*, **6** : 215.
1918. *Aphis malvoides*, Das, *Mem. Indian Mus.*, **6** : 215.
1918. *Aphis bauhiniae*, Theobald, *Bull. ent. Res.*, **8** : 279.
1921. *Toxoptera leonuri*, Takahashi, *Aphididæ Formosa*, **1** : 41.
1921. *Aphis shirakii*, Takahashi, *Aphididæ Formosa*, **1** : 58.
1927. *Aphis gossypii*, Theobald, *Brit. Aphid.*, **2** : 141.

This well known aphid is very common on cotton and melon in America, Africa, China and Formosa. In England and the United States of America it has also been found to be a vector of virus diseases such as the mosaics of cauliflower, cucumber, lily and bean, and the yellow-dwarf of onion.

At Coimbatore, it is reported to be sometimes very harmful to Cambodia cotton from December to August. At Bangalore and Poona, it occasionally assumes the status of a minor pest of cotton and brinjal.

This species is subject to great variation in size and colour, sometimes even on the same host. A large number of specimens collected from potato at Delhi in March, 1939 were more yellow in colour than green.

It is extremely polyphagous in habits and attacks a large number of cultivated and wild plants. At Delhi it has been found breeding on the following plants :—

Gossypium herbacium from September to February, rarely up to April ; *Solanum tuberosum*, December to March ; *Capsicum* spp., September to April ; *Althaea rosea*, November to March ; *Abutilon indicum*, December to April ; *Hibiscus esculentus*, September to November ; *Solanum melongenum*, February to April ; *Nicotiana tabacum*, February to April ; *Citrulus vulgaris*, April to June ; *Luffa aegyptiaca*, August to September ; and *Crotalaria juncea*, August to September.

It is not very serious on any of these plants at Delhi. Cotton also escapes from damage, as the aphid makes its appearance in Delhi rather late in the season.

Aphis maidis Fitch

(Fig. 3)

1856. *Aphis maidis*, Fitch, *Trans. N. Y. St. agric. Soc.*, **15** : 550.
1915. *Aphis sorghi*, Theobald, *Bull. ent. Res.*, **6** : 128.
1917. *Siphonaphis maidis*, Van der Goot, *Contr. Faun. Nederlandsch-indie*, **1** : 67.
1918. *Aphis maidis*, Das, *Mem. Indian Mus.*, **6** : 208.

This aphid has a world-wide distribution and is particularly serious on corn in America, where it is called the "corn-aphid". In the West-

Indies it is a vector of *Saccharum* virus I, causing the sugarcane mosaic. It is also suspected to be a vector of this disease in India, but so far, it has not been proved experimentally to be so.

Das (*loc. cit.*) recorded it from the common graminaceous crops at Lahore. Occasionally, it is serious on *Andropogon sorghum* at Coimbatore and on *Eleusine coracana* (*ragi*) at Bangalore. At Delhi, it occurs on the following host plants :—*Triticum sativum*, December to March ; *Hordeum vulgare* and *Avena sativa*, December to March ; *Andropogon halepensis*, April-May ; and *Sorghum vulgare*, *Zea mays* and *Panicum* spp., July to November.

Except for the month of June or early July, this aphid continues to breed all the year round at Delhi. Although it does not feed normally on sugarcane, a light infestation was observed during October-November, 1938 on the *sakharchinia* variety, growing in the experimental plots of the Plant Pathologist, I. A. R. I., New Delhi.

Aphis laburni Kaltenbach

1843. *Aphis laburni*, Kaltenbach, *Monogr. Pflanzenlause*, 85.
1854. *Aphis medicaginis*, Koch, *Die Pflanzenlause* (*Aphiden*) 94, figs. 125-126.
1815. *Aphis leguminosae*, Theobald, *Bull. ent. Res.*, **6** : 11, 121, fig. 16.
1916. *Aphis rumicis*, Maki, *Bull. agric. expt. Sta. Formosa*, **108** : 36.
1922. *Aphis cistiella*, Theobald, *Bull. Soc. R. ent. Egypte*, **7** : 45.
1927. *Aphis laburni*, Theobald, *Brit. Aphid.*, **2** : 122.

This shiny-black aphid has a world-wide distribution, occurring mainly on leguminous plants. Das recorded it on a number of plants in the Punjab. It is reported to be serious on *Dolichos lab-lab* at Coimbatore and Bangalore and on beans at Poona.

At Delhi, I have found it breeding on the following hosts :—*Cicer arietinum* and *Lens esculenta*, January to March ; *Medicago sativa*, throughout the year except in May and June ; *Trifolium alexandrinum*, *Medicago lupulina*, *Medicago denticulatus* and *Cajanus cajan* December to March ; *Dolichos lab-lab*, February to April ; *Lathyrus sativus*, January to April ; *Vigna catjang*, July to October ; *Phaseolus mungo*, August to October ; and *Tribulus terrestris*, May and July to September.

Aphis rumicis Linnaeus

1758. *Aphis rumicis*, Linnaeus, *Syst. Nat.* (ed. 10), **1** : 451.

Theobald (1929) has given full synonymy and description of this species. It is a cosmopolitan species. In Europe and America it is recorded from a very large number of plants and has been proved to be a vector of virus diseases of sugar-beet, bean, pea, white-clover and onion. At

Bangalore it is found throughout the year on *Vigna catjang*. George recorded it on *Solanum nigrum* from Coimbatore. Das found it breeding on *S. nigrum, Cnicus arvensis, Rumex dentata, Chenopodium* sp. and *Pyrus communis* in the Punjab.

In Delhi and Karnal, I collected it on *Solanum nigrum*, its favourite host in this area. It feeds on the under surface of leaves, which are turned into curious shapes.

Aphis nerii Fonscolombe

1841. *Aphis nerii*, Fonscolombe, *Ann. Soc. ent. Fr.*, **10** : 179.
1879. *Aphis lutescens*, Monell, *Bull. U. S. Geol. Geogr. Surv.*, **5** (1) : 23.
1931. *Aphis nerii*, Hottes & Frison, *Bull. Nat. Hist. Surv. Illinois*, **19** : 206.

This species can easily be recognised by the orange-yellow colour of its abdomen, on which the black cornicles stand out conspicuously.

This species has previously been recorded from Lahore, Coimbatore, Bellary and Bangalore.

I have often noted it clustering on the leaves of *Calotropis* spp. at Delhi, Rohtak and Karnal from February to April.

Aphis sacchari Zehntner

(Figs. 5, 6)

1901. *Aphis sacchari*, Zehntner, *Arch. Suikerind. Nederlandische-indie*, **9** : 674.
1917. *Longiunguis sacchari*, Van der Goot, *Contr. Faun. Nederlandische-indie*, **1**, (3) : 116.
1921. *Aphis miscanthi*, Takahashi, *Aphididæ Formosa*, **1** : 54.
1921. *Aphis formosanus*, Takahashi, *Aphididæ Formosa*, **1** : 55.
1931. *Aphis sacchari*, Takahashi, *Rep. Dept. Agric. Res. Inst. Formosa*, **53** : 43.

This aphid is distributed in China, Formosa, Japan, Hawaii, Philippines, Java, India, Africa, and South America. In India, it was previously recorded from Coimbatore, Mysore, Poona and Lahore, mostly on sorghum, seldom on sugarcane.

I collected it at Delhi and Karnal on sugarcane in October-November and on ratoon *jowar* (*Sorghum vulgare*) from November to April. On the latter host it breeds extensively in company with *Aphis maidis* Fitch.

Hyalopterus Koch

1781. *Aphis* (partim), Fabricius, *Spec. Ins.*, **2** : 385.
1854. *Hyalopterus*, Koch, *Die Pflanzenläuse* (*Aphiden*), 16.
1917. *Hayhurstia*, Del Guercio, *Redia*, **20** : 208.
1927. *Hyalopterus*, Theobald, *Brit. Aphid.*, **2** : 17.

Genotype.—*Hyalopterus arundinis* (Fabricius)

Head without any frontal tubercles ; antennæ six-segmented, with flagellum longer than base ; sensoria circular. Cornicles very short, more or less swollen beyond middle, especially in alatæ. Cauda long and broad, longer than cornicles.

Hyalopterus atriplicis (Linnaeus)

1746. *Aphis atriplicis*, Linnaeus, *Faun. Suecica*, 1000.
1761. *Aphis atriplicis*, Linnaeus, *Faun. Su. ed. altera*, 262.
1801. *Aphis chenopodii*, Shrank, *Faun. Boica*, **2** : 109, 1196.
1917. *Hayhurstia atriplicis*, Del Guercio, *Redia*, **12** : 208.
1918. *Brevicoryne chenopodii*, Das, *Mem. Indian Mus.*, **6** : 183.
1927. *Hyalopterus atriplicis*, Theobald, *Brit. Aphid.*, **2** : 26-29.

Widely distributed in North America, Europe and Formosa. Das recorded it on *Chenopodium* sp. at Lahore. I have collected it from the same host at Delhi from November to April and sometimes up to May in sheltered places. The infested leaves of this weed are turned into boat-shaped pseudo-galls. Large colonies of aphids (apterous viviparous females) are found thriving inside these galls. The winged forms are found on the leaves outside the galls.

Toxoptera Koch

1857. *Toxoptera*, Koch, *Die Pflanzenlause* (*Aphiden*), 253.
1891. *Ceylonia*, Buckton, *Indian Mus. Notes*, **2** : 35.
1927. *Toxoptera*, Theobald, *Brit. Aphid.*, **2** : 319.

Genotype.—*Toxoptera aurantii* (Fonscolombe)

Head without antennal tubercles, but with a median process. Antennæ six-segmented, with circular sensoria. Cornicles cylindrical, of moderate length, somewhat tapering near apices. Cauda similar to that in *Aphis*. Fore-wings with media once-branched.

Toxoptera graminum (Rondani)

1852. *Aphis graminum*, Rondani, *Nuovi. Ann. Soc. Nat. Bologna*, (3) **6** : 9-12.

This is the only species of this genus which has been obtained from the Delhi area. At Delhi it is found sparingly on wheat, barley and *jowar* from February to April.

In America it is a well known pest of corn and is spoken of as the "green-bug" or "spring green-aphid". It is reported to be very injurious to corn in Africa also.

At Coimbatore it has been recorded on wheat and *ragi* in fair numbers from August to October. Das recorded it from wheat, oat, barley, *Cyperus* spp. and *Cynodon dactylon* at Lahore.

As has been shown by experience in America and elsewhere, it should be looked upon as a potential major pest.

Rhopalosiphum Koch

1854. *Rhopalosiphum*, Koch, *Die Pflanzenlause* (*Aphiden*), 23.
1860. *Siphocoryne*, Passerini, *Gli Afidi*, 28.
1910. *Coloradoa*, Wilson, *Ann. ent. Soc. Amer.*, **3** : 323.
1915. *Siphonaphis*, Van der Goot, *Beitrage Kennt. Holl. Blattlause*, 238.
1918. *Stephensonia*, Das, *Mem. Indian Mus.*, **6** : 175.
1927. *Rhopalosiphum*, Theobald, *Brit. Aphid.*, **2** : 57-58.

Genotype.—*Rhopalosiphum nymphæ* (Linnaeus)

Head without any prominent frontal tubercles; antennæ six-segmented, with circular sensoria. Cornicles moderately long and narrow, slightly swollen towards the apical region. Cauda elongate, not as long as cornicles.

Rhopalosiphum pseudobrassicae (Davis)

(Figs. 10, 11)

1914. *Aphis pseudobrassicae*, Davis, *Canad. Ent.*, **46** : 231.
1917. *Siphocoryne pseudobrassicae*, Van der Goot, *Contrib. Faun. Nederlandische-indie*, **1** : 64.
1918. *Siphocoryne indobrassicae*, Das, *Mem. Indian Mus.*, **6** : 188.
1921. *Rhopalosiphum papaveris*, Takahashi, *Aphididæ Formosa*, **1** : 34.
1931. *Rhopalosiphum pseudobrassicae*, Takahashi, *Rep. Dept. Agric. Res. Inst. Formosa*, **53** : 52.

Widely distributed all over the world, it was previously recorded in India from Poona, Coimbatore and Bangalore on cruciferous plants, on which it sometimes occurs as a serious pest.

In spring this aphid is generally found in Delhi in large numbers on mustard, radish, knolkohl, cabbage, etc. The inflorescence is thickly covered and the yield is adversely affected, very few pods being allowed to set. The leaves are profusely covered over with an oily-looking excreta and honey-dew secreted by the aphids. In addition to cruciferous crops, this aphid is also found on tobacco and potato at Delhi.

It makes its appearance early in November and occurs in the field up to April. In the spring of 1937, it was so abundant in Delhi and the adjoining areas that there were large swarms of winged adults, especially in the months of February and March.

Brachyunguis Das

1918. *Brachyunguis*, Das, *Mem. Indian Mus.*, **6** : 227.

This genus was erected by Das with *harmalæ* as the type. Baker (1920) considered it a synonym of *Pergandeida* Schouteden; but Borner considered it to be distinct. I agree with Borner in that the characters of *Brachyunguis* are distinct from those of *Pergandeida*. In the former the flagellum of the sixth antennal segment is shorter than the base and the cornicles about

twice as long as broad, whereas in the latter the flagellum is distinctly longer than the base and the cornicles are short, almost as wide as long.

Brachyunguis carthami Das

(Figs. 7, 8)

1918. *Brachyunguis carthami*, Das, *Mem. Indian Mus.*, **6** : 237.

Das recorded this aphid from Lahore on wild safflower (*Carthamus oxycarpi*). I found it breeding in very large numbers on the same plant in May, 1939 and on another unidentified weed in March, 1938 at Delhi. On account of the thick mealy-coat on their bodies the aphids are ashy-grey in colour. It is interesting to note that the cultivated safflower, growing quite adjacent to the wild variety, was absolutely free from this insect.

Brevicoryne Van der Goot

1915. *Brevicoryne*, Van der Goot, *Beitrage Kennt. Holl. Blattlause*, 245.
1916. *Oedisiphum*, Van der Goot, *Zur Kennt. Blattlause Java*, 122.
1918. *Brevicoryne*, Das, *Mem. Indian Mus.*, **6** : 179.
1927. *Brevicoryne*, Theobald, *Brit. Aphid.*, **2** : 44.

Genotype.—*Brevicoryne brassicae* (Linnaeus)

Head without any frontal tubercles ; antennæ six-segmented, with circular sensoria in alate forms. Cornicles short, swollen in the middle, slightly longer than cauda. Cauda short and broadly conical. Venation normal.

Brevicoryne brassicae (Linnaeus)

(Fig. 4)

1758. *Aphis brassicae*, Linnaeus, *Syst. Nat.*, (ed. 10), **2** : 734.
1906. *Siphocoryne brassicae*, Shouteden *Mem. Soc. ent. Belgie*, **12** : 217.
1915. *Brevicoryne brassicae*, Van der Goot, *Beitrage Kennt. Holl. Blattlause*, 245.

This is the cosmopolitan *Brassica* plant-louse, very injurious, ruining whole fields of cabbage, cauliflower, mustard and other cruciferous crops in Europe and America. Das recorded it on cabbage and turnip at Lahore. At Delhi it was collected on almost all cruciferous plants, particularly on cabbage, cauliflower and raddish from November to May. Even in early June it is found taking shelter and breeding under cabbage leaves. The infestation is generally not serious in the Delhi area.

Therioaphis Walker

1870. *Therioaphis*, Walker, *Zoologist*, **5** : 1999.
1905. *Kallistaphis*, Kirkaldy, *Canad. Ent.*, **37** : 417.

1906. *Eucallipterus*, Schouteden, *Ann. Soc. ent. Belgie*, **30** : 31.
1915. *Neocallipterus*, Van der Goot, *Beitrage Kennt. Holl. Blattlause*, 320.
1927. *Therioaphis*, Theobald, *Brit. Aphid.*, **2** : 363.

Genotype.—*Therioaphis ononidis* (Kaltenbach)

Cornicles truncate ; in some constricted near apex ; antennæ six-segmented, moderately long, with elongate-oval sensoria ; no hairs on the antennæ. Prothorax rather elongate. Cauda knobbed. Anal plate bilobed, lobes rather long. Wings normal, variously adorned. Body covered with prominent hairs, which are often capitate.

Therioaphis ononidis (Kaltenbach)

1846. *Aphis ononidis*, Kaltenbach, *Ent. Zeit.*, **3** : 173.
1857. *Chaitophorus ononidis*, Koch, *Die Pflanzenlause* (*Aphiden*), 5.
1863. *Myzocallis ononidis*, Passerini, *Aphidol. Ital.*, **53**.
1870. *Therioaphis ononidis*, Walker, *Zoologist*, **5** : 1999.
1882. *Callipterus trifolii*, Monell, *Canad. Ent.*, **16** : 14.
1899. *Chaitophorus maculatus*, Buckton, *Indian Mus. Notes*, **4** : 277.
1915. *Callipterus ononidis*, Theobald, *Bull. ent. Res.*, **6** : 134-138.
1927. *Therioaphis ononidis*, Theobald, *Brit. Aphid.*, **2** : 363-367.

This is the yellow "clover-aphid" of America. It is widely distributed in Europe, North America, India and Egypt. In America and Egypt it is very injurious to clover. Previously it is recorded in India on *Medicago sativa* at Mysore, Lahore, and Poona. At the latter place it becomes harmful to clover during the summer months.

At Delhi it has been found feeding on lucerne, berseem, *Cyperus rotundus* and *Medicago lupulina* from August to May. The aphids are very sensitive. With the slightest touch or shake of the twig they fall to the ground. After remaining perfectly still for a short time they climb up the plant again.

Myzus Passerini

1860. *Myzus*, Passerini, *Gli Afidi*, 27.
1860. *Rhopalosiphum*, Passerini, *Gli Afidi*, 27.
1916. *Neomyzus*, Van der Goot, *Beitrage Kennt. Holl. Blattlause*, 50.

Genotype.—*Myzus cerasi* (Fabricius)

Frontal tubercles distinct, projecting inwards and are strongly gibbous, especially in apterous forms. Antennæ six-segmented, about equal to the body in length. First antennal segment gibbous. Cornicles rather long, cylindrical. In some they are swollen in places, but never really clavate. Cauda prominent, somewhat conical, may be slightly constricted, half to almost equal the length of cornicles. Wing venation normal.

Myzus persicae (Sulzer)

(Figs. 1,2)

1776. *Aphis persicae*, Sulzer, *Abgek. Gesch. Ins.*, 105.
1801. *Aphis dianthi*, Shrank, *Faun. Boica*, **2** : 114.
1857. *Rhopalosiphum dianthi*, Koch, *Die Pflanzenlause* (*Aphiden*), 42.
1875. *Myzus persicae*, Buckton, *Mon. Brit. Aphid.*, **1** : 178.
1926. *Myzus persicae*, Theobald, *Brit. Aphid.*, **1** : 318-322.

This is a cosmopolitan and an extremely polyphagous species feeding on several wild and cultivated plants. It is commonly known as the peach green-aphis, because it does considerable damage to peach and plum. In India, it has been found to be very harmful to these fruit trees in Baluchistan and the N. W. F. Province. In the plains, it is common on mustard, cauliflower, tobacco and potato during spring.

The following are some of the important host plants on which it has been found at Delhi from November to April :—

Solanum tuberosum, *Nicotiana* spp., *Brassica rapa*, *Raphanus sativus*, *Brassica compestris*, *Brassica juncea*, *Althaea rosea*, *Carthamus tinctorius*, *Brassica oleracea cauliflora*, *Brassica oleracea*, *Beta vulgaris*, *Orobanche* sp. *Malva sylvestris*, *Marcona grandiflora*, *Convolvulus* sp., *Phlox* spp., *Beta bengalensis* and *Solanum indicum*.

In England and the United States of America, it has been found to be a vector of at least twenty-one virus diseases, especially among the Solanaceae and Cruciferae. In India there is no data on this aspect but it is probable that at least some of the diseases, particularly in Solanaceae, may be transmitted by this aphid.

Macrosiphum Passerini

1855. *Siphonophora*, Koch, *Die Pflanzenlause* (*Aphiden*), 150.
1860. *Macrosiphum*, Passerini, *Gli Afidi*, 27.
1887. *Nectarophora*, Oestlund, *Bull. Minnesota Geol. Surv.*, **4** : 78.
1913. *Macrosiphon*, Del Guercio, *Redia*, **5** : 188.
1920. *Macrosiphum*, Baker, *Bull. U. S. Dept. Agric.*, **826** : 57.

Genotype.—*Macrosiphum rosæ* (Linnaeus)

Frontal tubercles very prominent, markedly divergent ; antennæ long, as long as or longer than the body, six-segmented ; flagellum long, third-segment longer than fourth ; sensoria circular. Cornicles long, cylindrical, rather thin and often tapering towards apex. Cauda long, lanceolate or ensiform, often constricted near the middle. Wings normal.

The following species of this genus have so far been collected at Delhi :—

Macrosiphum granarium (Kirby), *M. pisi* (Kalt.), *M. solidaginis* (Fab.) and *M. rosaeiformis* Das.

Key to the species from Delhi

1. Cornicles markedly reticulate at apices 2
   Cornicles with no reticulations (imbricate) ..... *M. pisi*
2. Cauda green 3
   Cauda black (body dark-brown) ..... *M. solidaginis*
3. Hosts Gramineæ. Apterous viviparious female oval, short and conical ..... *M. granarium*
   Hosts *Rosa* spp. Apterous viviparious female almost linear, elongate oval ..... *M. rosaeiformis*

Macrosiphum pisi (Kaltenbach)

1843. *Aphis pisi*, Kaltenbach, *Mon. Pflanzenlause*, 23.
1855. *Siphonophora pisi*, Koch, *Die Pflanzenlause (Aphiden)*, 190.
1914. *Acyrthosiphon pisi*, Mordwilko, *Faun. russe Hem.*, **1** : 83.
1926. *Illinoia pisi*, Campbell, *J. agric. Res.*, **32** : 861.
1926. *Macrosiphum pisi*, Theobald, *Brit. Aphid.*, **1** : 127-130.

This is a large-sized green aphis known as the "green pea-louse" or "green dolphin" in America. In Europe and America it is very injurious to peas and beans and is also a vector of at least eight virus diseases.

Das recorded it from Lahore on the following host plants :— *Alhagi maurorum, Melilotus alba, Medicago sativa, M. falcatum, Clianthus dampieri, Lathyrus odoratum* and *Peganum harmalae* from February to April and on *Dolichos lab-lab* in August.

At Delhi, I collected it on *Medicago lupulina, M. denticulatus* and *M. sativa* during February to April.

Macrosiphum solidaginis (Fabricius)

1797. *Aphis solidaginis*, Fabricius, *Ent. Syst.*, **4** : 211.
1855. *Siphonophora solidaginis*, Koch, *Die Pflazenlause (Aphiden)*, 197.
1875. *Siphonophora solidaginis*, Buckton, *Mon. Brit. Aphid.*, **1** : 156.
1926. *Macrosiphum solidaginis*, Theobald, *Brit. Aphid.*, **1** : 98.

This is a large, dark-brown aphid, previously recorded from England, New Mexico and Java on a number of plants. Das recorded it on *Sonchus* spp. from Lahore. It is also reported to be a serious pest of safflower in the Ceded-Districts in South India during January and February.

At Delhi and Rohtak, it breeds in large numbers on safflower from January to April. The top-shoots are generally literally covered up with the aphids, with the result that plant-growth gets stunted.

Macrosiphum granarium (Kirby)

1798. *Aphis granaria*, Kirby, *Trans. Linn. Soc.*, **4** : 238.
1843. *Aphis cerealis*, Kaltenbach, *Mon. Pflanzenlause*, 16.
1849. *Aphis avenae*, Walker, *Ann. Mag. Nat. Hist.*, (2) **5** : 3, 45.

1876. *Siphonophora granaria*, Buckton, *Mon. Brit. Aphid.*, **1** : 114.
1921. *Macrosiphum miscanthi*, Takahashi, *Aphididæ Formosa*, **1** : 8.
1926. *Macrosiphum granarium*, Theobald, *Brit. Aphid.*, **1** : 70.

This is the large wheat plant-louse, which can be easily recognised by its green colour and black, apically-reticulated cornicles. It occurs all over Europe, America, Japan, Formosa, Java and Africa. Das recorded it from Lahore on wheat, barley and oat.

At Delhi, it infests several graminaceous crops from November to April. In certain years it becomes serious on wheat and barley but is easily brought under check by predators such as, syrphid maggots and coccinellids. It is also found in small numbers on oat, maize and *jowar*.

Macrosiphum rosaeiformis Das

1918. *Macrosiphum rosaeiformis*, Das, *Mem. Indian Mus.*, **6** : 159.

Das called it as the "Punjab rose-aphid" and recorded it on several species of roses from Lahore. It is a minor pest of roses in Coimbatore and the Nilgiris. I noticed a heavy infestation of this aphid on roses in March, 1938 in a garden near Subzimandi, Delhi. Rose plants growing in several bungalows of the Imperial Agricultural Research Institute, New Delhi, are sometimes severely attacked in spring. A closely allied species, *M. rosæ* (Linn.), is known to be a pest of roses in other parts of the world.

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(*Received for publication on* 30. iii. 1940).

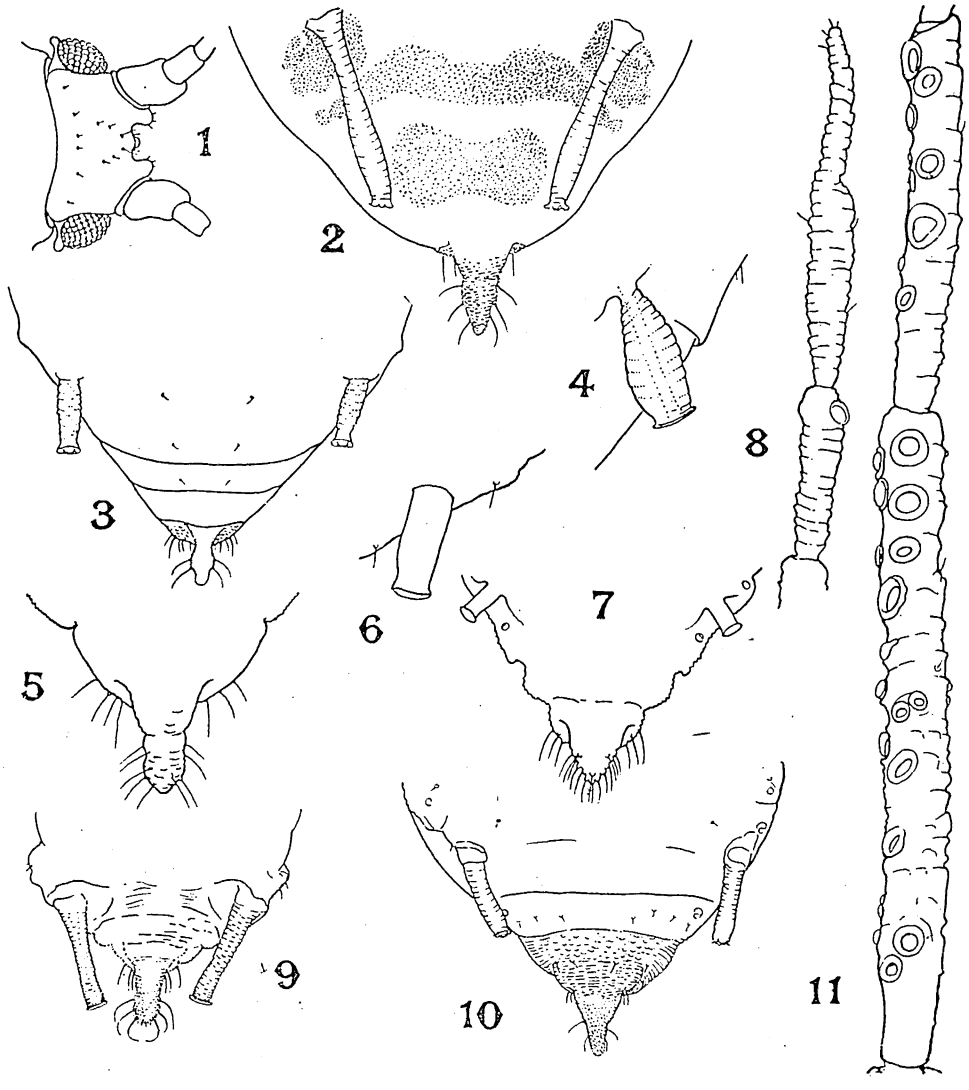

FIG. 1. *Myzus persicae* (Sulz.), head.
FIG. 2. *Myzus persicae* (Sulz.), cornicles, cauda and dark patches on the hind portion of the abdomen.
FIG. 3. *Aphis maidis* Fitch, cornicles and cauda.
FIG. 4. *Brevicoryne brassicae* (Linn.) cornicle.
FIG. 5. *Aphis sacchari* Zehnt., cauda.
FIG. 6. *Aphis sacchari* Zehnt., cornicle.
FIG. 7. *Brachyunguis carthami* Das, cornicles and cauda.
FIG. 8. *Brachyunguis carthami* Das, fifth and sixth antennal segments.
FIG. 9. *Aphis gossypii* Glover, cornicles and cauda.
FIG. 10. *Rhopalosiphum pseudobrassicae* (Davis), cornicles and cauda.
FIG. 11. *Rhopalosiphum pseudobrassicae* (Davis), third and fourth antennal segments.

(In the above figures the organs illustrated are of alate viviparous females)

THE MORPHOLOGY OF THE GENITALIA IN THE ALEURODIDÆ (HOMOPTERA) AND THEIR MODE OF WORKING

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(*Communicated by Dr. S. Pradhan*)

CONTENTS

I. INTRODUCTION

Although the male genitalia of the division Sternorhyncha in general have been described and sketched by Pruthi (1925) and some other workers, no detailed account of the morphology of these organs in the family Aleurodidæ is yet available. Since genitalia have proved to be of taxonomic importance in several groups of insects, the writer has made a close study of these structures in this family. Moreover, while collecting specimens of *Dialeurodes eugeniæ* Maskell during the months of October and November, 1938, I came across several copulating specimens which gave me an opportunity to observe the process of copulation and study the working of various components of the genitalia in the process. The only reference to the details of copulation in Rhynchota the writer could find was that in the case of *Naucoris* (Heteroptera) by Rawat (1939). Pruthi (1925) also briefly described this process in this order and stated : "the whole of the ædeagus (in Homoptera) functions as the intromittent organ. The powerful muscles—the protractors and the retractors—attached to the dorsal and ventral regions, respectively, of the basal plates are responsible for the eversion and the retraction of the ædeagus". In fact the musculature of the genitalia and their functions have been insufficiently studied in Rhynchota in general and Homoptera in particular. The results of writer's studies on the morphology and musculature of the genitalia of the Aleurodidæ and their mode of working are described in the following pages.

II. MATERIAL AND TECHNIQUE

The following species have been examined :—*D. eugeniæ*, *Aleurodes schizuokensis* Kuwana, *Aleurotulus maculata* Singh, *Dialeurodes dissimilis* Q. & B., *D. kirkaldyi* Kot, *D. pallida* Singh, *Aleurodiscus holmsii* Maskell, *Trialeurodes bicoler* Lamba, *T. ricini* Misra, *Aleurotuberculatus steriospermi* Corbett, *Aleurodiscus burmiticus* Cockrell. The process of copulation has been studied in detail in the case of *D. eugeniæ* only.

The material was collected in Lucknow and at Pilibhit, during the months of August, September and October, 1938. The specimens for the study of genitalia were either killed in 90% alcohol or with chloroform and preserved in 90% alcohol. To study the genitalia, the abdomen of the insect was kept in 10% solution of KOH and allowed to remain there for a period varying from 12 to 36 hours according to the size of the specimen. The genitalia were stained with picric acid dissolved in oil of cloves as suggested by Pruthi (1925). For a study of the musculature, the dissections were made in a 1% solution of eosin. Copulating pairs were killed in a potassium cyanide tube. The material for section-cutting was fixed in alcoholic Bouin, and stained with hæmatoxylin and eosin. Drawings were made with camera luncida.

III. THE GENITALIA IN *Dialeurodes eugeniæ* MASKELL

1. *The male genitalia*

The terminology followed in this paper is adopted from Pruthi (1925).

The 9th abdominal segment (IX) though smaller than the 8th (VIII), is fairly large in size, and its tergal region extends further backwards than the sternal (*sm*), so that its lateral regions which are very broad, are disposed obliquely (Fig. 1). This segment may be called the genital segment, but not in the same sense as in Heteroptera[1]. The 10th segment (X) which bears the anus on the dorsal surface is very small and has no distinct sternal plate. The inter-segmental membrane (*s.me.*) between the 9th and the 10th segments is large, and the ædeagus (*ae*) appears to originate from the under surface of this membrane. The 11th segment (XI) is smaller than the 10th and consists only of the tergal plate and an elongated spine-like structure which is called the anal style (*as*), there being no sternal plate in this segment.

The male genitalia consist of three distinct parts : (i) the ædeagus, (ii) a pair of parameres, and (iii) the basal plates. The relation of these elements to one another and their normal disposition can be seen by a reference to Fig. 1.

1. In Heteroptera the male genitalia lie within the genital segment at the time of rest, while in Homoptera they lie outside the genital segment; therefore the term genital segment cannot be used in the same sense in the two sub-orders.

(*i*) The ædeagus (*ae*) is an elongated tube, about 0.2 mm. in length, curved in the distal region, thus more or less resembling a sword-scabbard. The proximal end is wide and bears a basal foramen (*bf*), exactly through the middle of which the ductus ejaculatorius (*de.j.*) enters the ædeagus. The border of the basal foramen (*b.bf.*) is very much thickened and one of its sides projects anteriorly. The projection is solid and is highly thickened and chitinised, thus forming an apodeme, the *phallic apodeme* (*ae. ap.*), for muscular attachment. It is possible to trace the ductus into the ædeagus right upto the distal end which is very narrow; beyond this place, the walls of the ductus become closely applied to those of the ædeagus and the ductus is not visible separately, but in the newly hatched males where the chitin is very thin and almost colourless the ductus can be traced right upto the very tip of the ædeagus.

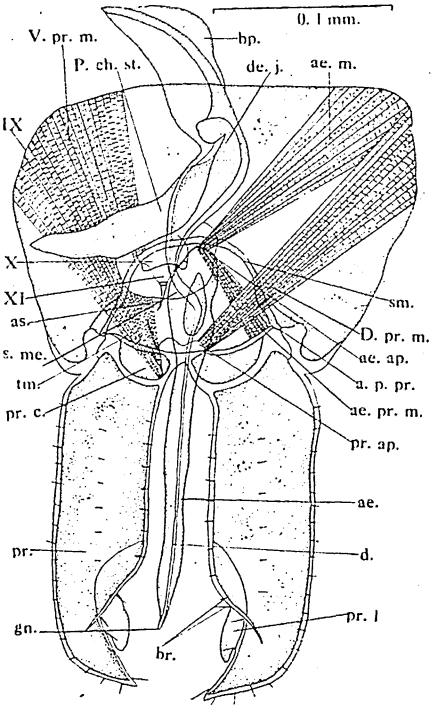


Fig. 1.—Male genitalia of *D. eugeniæ* with their musculature. The muscles of only one side are shown. *ae.*, ædeagus; *ae. ap.*, phallic apodeme; *ae. m.*, phallic muscles; *ae. pr. m.*, phallic-parameral muscles; *a. p. pr.*, articulating point of paramere with the segment; *as.*, anal style; *bf.*, basal foramen; *bp.*, basal plate; *br.*, bristles; *d.*, duct; *de. j.*, ductus ejaculatorius; *D. pr. m.*, dorso-parameral muscles; *gn.*, gonopore; *P. ch. st.*, posterior chitinous structure; *prl.*, parameres; *pr. ap.*, parameral apodeme; *pr. c.*, parameral cavity; *br.* l., parameral lobe; *sm.*, sternal margin; *s. me.*, segmental membrane; *tm.*, tergal margin; *V. pr. m.*, ventro-parameral muscles; IX, X, XI, ninth, tenth, eleventh segments.

The ductus ejaculatorius originates from the region of the basal plates as a highly chitinised sac-like structure, into which open a pair of ejaculatory ducts. The sac leads into a long, thin-walled and shining duct (*d*), which enters the ædeagus.

(*ii*) The parameres (*pr*) are long, flattened and leaf-like structures, one on each side of the ædeagus. The outer corner of the proximal end of each paramere articulates with the segment at the place where the sternum and the tergum meet posteriorly (*a.p.pr.*), while the inner corners of the two fuse together in the middle line. This fused median piece of the two parameres is very thick and highly chitinised and shows two anterior projections. When seen from the dorsal side, these projections appear dome-shaped and may be termed as *parameral apodeme* (*pr.ap.*), since they provide for the attachment of various muscles. Each paramere is

about 0.2 mm. in length, and about 0.05 mm. in thickness proximally, while distally it tapers and becomes very narrow near the tip. The outer edge of each paramere is straight and smooth, while the inner edge bears a lobe-like structure (*lb*), close to its distal end, which also bears long bristles, while small bristles arranged in longitudinal rows are found all over its surface.

(*iii*) The basal plates (Figs. 1 & 2, *bp*) are really paired structures which fuse together to form a single plate, but their paired character is evident from the bifid nature of the anterior part (*b.bp.*). Dorsally the plate appears T-shaped, the stem of the T being the baso-platal prolongation (*bp.po.*). The basal plate with its prolongation is very highly chitinised. The posterior portion of the stem shows a more or less circular area (*bp.b.*) on the dorsal side, which appears like an opening but is actually only an area of incomplete chitinisation (comparable to the rudiments of the basal plate bridge of Cicadidæ). The sac of the ductus is attached to the base of the plates. A very highly chitinised boat-shaped structure (*P.ch.st.*) is attached to the sac. This structure gives attachment to the baso-platal muscles. A similar chitinous structure, but smaller in size, is formed by the basal plates anteriorly for the same muscles.

Musculature of the male genitalia and their mode of working

The muscles which take part in the working of the different components of the genitalia may be described under the following categories and are shown in Figs. 1 & 2 :—

i. The baso-platal muscles.
ii. The phallic muscles.
iii. The phallic-parameral muscles.
iv. The dorso-parameral muscles.
v. The ventro-parameral muscles.

(*i*) The baso-platal muscles (Fig. 2, *bp.m.*) originate from the dorsal and ventral surfaces of the anterior part of the basal plates, and run on either side of the baso-platal prolongation to be inserted both dorsally and ventrally on the posterior chitinous structure of the basal plates. All the muscle-bands run straight and longitudinally in the antero-posterior direction and are situated symmetrically on the right and left sides of the baso-platal prolongation. These muscles are very thick and powerful. The ventral muscles are known as *retractors* (*re*), while the dorsals are called *protractors* (*po*). These muscles are responsible for the retraction and eversion of the ductus ejaculatorius in and out of the ædeagus.

(*ii*) The phallic muscles (Fig. 1, *ae.m.*) originate fan-wise from the antero-lateral corners of the dorsal surface of the 9th sternum, one on each

side, and are inserted on the apodeme (*ae.ap.*) at the base of the ædeagus. These are also very powerful muscles and lie ventrally to all the other muscles in this segment. These muscles are responsible for the penetration of the ædeagus into the bursa copulatrix.

(*iii*) The phallic-parameral muscles (*ae.pr.m.*) originate from the phallic apodeme (*ae.ap*) on either side and are inserted on the antero-lateral corners of the parameres. These thick muscles lie parallel to one another and contract as soon as the phallic muscles contract. The contraction of these muscles draws together the tips of the parameres which cross each other so that the female genitalia lie between them, on account of the presence of the parameral lobes. The parameres thus hold the female genitalia tightly as long as the ædeagus remains within the uterus.

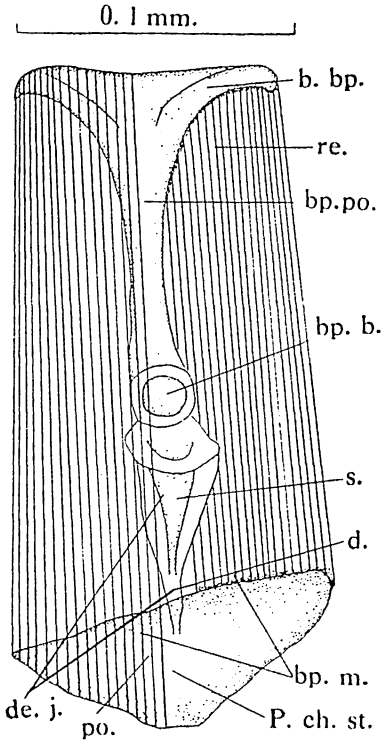


Fig. 2.—The basal plate with its muscles. *b. bp.*, bifid condition of the basal plate ; *bp. b.*, basal plate bridge ; *bp. m.*, baso-platal muscles ; *bp. po.*, baso-platal prolongation ; *po.*, protractors ; *re.*, retractors ; *s.*, sac. Other letterings as in fig. 1.

(*iv*) The dorso-parameral muscles (*D.pr.m.*) originate fan-wise from the lateral margins of the tergum of the 9th segment, and are inserted on the parameral apodeme (*pr.ap.*). The contraction of these muscles brings the parameres very close to each other so that their tips touch each other.

(*v*) The ventro-parameral muscles (*V.pr.m.*) also originate fan-wise from the 9th segment between the phallic muscles ventrally and the dorso-parameral muscles dorsally, and are inserted on the inner wall of the parameral cavity (*pr.c.*). These muscles are the strongest and their fibres are arranged in three groups. The contraction of these muscles brings the parameres back to their normal position after copulation is completed.

2. *The female genitalia* (Fig. 3)

The 9th (IX) segment is very large and accommodates the whole of the genitalia. The median oviduct (*od*) at its termination does not

open directly to the exterior, but its aperture, the gonopore (*gn*), is concealed in an inflection of the body-wall. This inflection is the bursa copulatrix (*b.co.*), which is more or less egg-shaped and receives the median oviduct at its anterior end. The spermatheca (*sp*) is a distinct structure, in shape very much like the musical pipe of a snake-charmer. The spermathecal duct (*sp.d.*) opens anteriorly, in the bursa. The bursa copulatrix is so called because it serves as a copulatory pouch during mating. Its external opening is known as the *vulva*.

The female genitalia consist of the (i) ovipositor and (ii) accessory structures.

(i) *The ovipositor.*—It consists of three pairs of valves which according to their position, may be called the dorsal (*D.v.*), ventral (*V.v.*), and inner (*I.v.*) valves. The dorsal and the inner valves belong to the 9th segment while the ventral valves belong to the 8th segment. The ventral valves occupy a ventro-lateral position. The region between the dorsal pair of valves is occupied by a thin membrane, the *intervalvular membrane* (*I.v.me.*), which bears the inner pair of valves. The dorsal and ventral valves are spear-shaped, each consisting of two parts, the body and the blade. The body is a more or less elongated plate, bearing the blade at its distal end. The blade is pointed and saw-like. Small bristles are found here and there all over the surface of the valves. The length of each dorsal valve is about 0.09 mm., while that of each ventral valve is about 0.1 mm. The inner valves consist of a pair of rod-like thickenings which are fused proximally but are free distally, and thus form an inverted V-shaped structure. The length of an inner valve is about 0.04 mm.

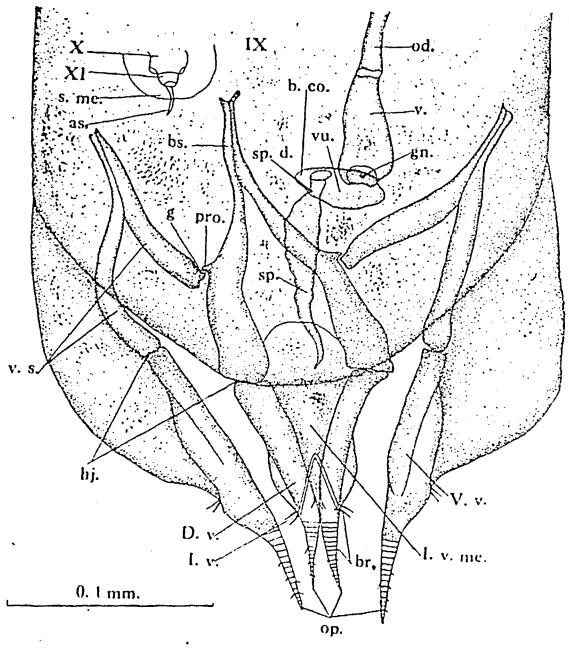


Fig. 3—The female genitalia and the terminal segments of *D. eugeniæ*. *b. co.*, bursa copulatrix; *bs.*, basal sclerite; *D. v.*, dorsal valve; *g.*, groove; *hj.*, hinge-joint; *I. v.*, inner valve; *I. v. me.*, inter-valvular membrane; *od.*, oviduct; *op.*, ovipositor; *pro.*, projection; *sp.*, spermatheca; *sp. d.* spermathecal duct; *v.*, vagina; *v. s.*, V-shaped sclerite; *vu.*, vulva; *V. v.*, ventral valve. Other letterings as in fig. 1.

(ii) *The accessory structures of the ovipositor.*—There is a fork-shaped chitinous structure known as the *basal sclerite* (*bs*), which lies in the 9th

segment. The stem of the fork is directed anteriorly and its tip is slightly flattened for the attachment of muscles, while each limb of the fork providing attachment for one of the dorsal valves is directed posteriorly. The joint (*hj*) between the arm of the fork on the one hand and the body of the dorsal valve on the other is a hinge-joint. At a little distance from the end of each limb of the fork there is a projection (*pro*) to which is attached a V-shaped (v) chitinous sclerite, one limb of which articulates with the projection, while the other limb is attached to the ventral valve. Each projection fits into a groove (*gr*) on the adjacent limb of the V, so that a movable joint is formed on which the V-shaped sclerite rotates. Thick muscle-bands originate from the apex of the V, and are inserted on the tip of the stem of the fork. There are other muscle-bands which originate from the junction of the two limbs of the V and are inserted on each limb of the fork. The exact function of these muscles is not understood.

IV. Copulation and Oviposition in *Dialeurodes eugeniæ* Maskell

A. *The process of copulation*

Copulating pairs of *D. eugeniæ* were very common during September and October, 1938, but were not much in evidence in November. The process of copulation is as follows :—

When a female is sitting quietly on a leaf of the food-plant, one, two or very often three males are attracted to it and take up their positions on its right and left. They may remain sitting in this position quietly for two to four hours, but generally after 4 to 10 minutes, the male which is furthest away from the female flies away. Shortly after, the male which is on the right side also flies away and thus only one male which is sitting on the left side of the female remains behind. After about 10 to 20 minutes, this male moves nearer and nearer the female and, sitting in front, touches the female antennæ with its own antennæ for two to three minutes. It moves again to the left side of the female, but always keeps touching the female with its antennæ. It takes up these two positions alternately five to ten times, and every time it comes to sit just in front of the female it touches the female antennæ with its antennæ. After these movements it comes to sit on the left side of the female, the two sitting side by side. After two to three minutes, it flutters its wings 8 to 10 times, and moves so close to the female as to be able to lay its right wing on the left wing of the latter. In this position the two remain sitting for 20 to 30 minutes. The female now flutters its wings a little, and the male moves its abdomen beneath the

left wing of the female. The latter again flutters its wings a little and the two are ready to copulate. By the contraction of the dorso-parameral muscles, the parameres of the male (Fig. 4) are brought together and hold the ovipositor (*op.*) between them. This is the proper copulating position. Now, by the contraction of the phallic muscles, the ædeagus is inserted into the vagina through the opening of the bursa, and at the same time the parameres hold the female genitalia very tightly by the contraction of the phallic-parameral muscles, even though the dorso-parameral muscles are relaxed. Since the phallic-parameral muscles can relax only on the relaxation of the phallic muscles, the female genitalia can be freed only when the ædeagus is retracted from the vagina. As described above, the basal plates have very powerful muscles attached to them, therefore when the ædeagus lies inside the bursa copulatrix, the posterior muscles by their contraction push the ductus ejaculatorius into the vagina. This is the copulating act proper. The alternate working of the protractors and retractors of the baso-platal muscles push in and pull out the ductus into and out of the vagina. The exact function of the muscles of the genitalia can be readily understood by reference to Figs. 1, 2 and 4.

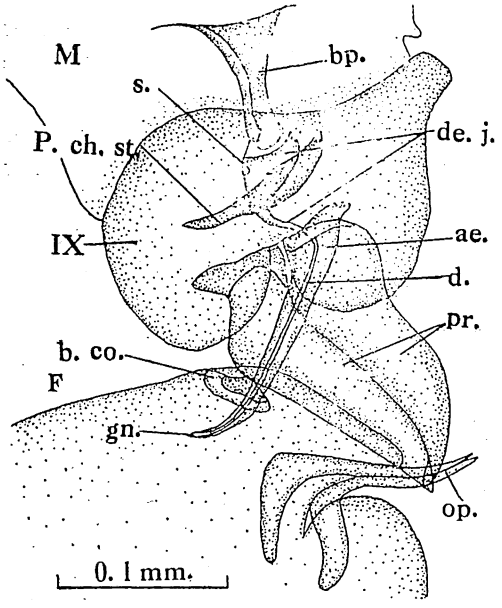


Fig. 4.—The male and female genitalia of *D. eugeniæ* in the copulating position. *F*, female; *M*, male. Other letterings as in figs. 1 and 3.

In the first position which the male and the female take at the time of copulation the angle between their bodies is about 45°. The copulation may be completed in this position. But generally after remaining in this position for about 10 minutes, the bodies of the male and female come to lie at right angles; the copulation may be completed even when the two remain in this position. But in most cases after some time the male comes to lie upside down, *i.e.*, with its back touching the surface of the leaf. When

the male is taking up this position, it moves its left side a little more beneath the body of the female and thus the angle between the two bodies comes to about 120°. In this position the wings of the male remain spreading outwards and forwards. Ultimately the male takes up a position completely beneath the female, the heads of the two being in the opposite direction, and the wings of the male remain spreading outwardly and anteriorly. The female jumps off a little and the wings of the male come back to their normal position. Thus the male lies with its back against the leaf and the female holds the male between herself and the leaf. The copulation lasts for 40 to 50 minutes and can take place at any time during 24 hours, but generally it is in the morning or the evening.

When copulation is completed, all the muscles concerned in bringing about the copulating adjustment of the various sclerites are relaxed ; now the ventro-parameral muscles contract and separate the two parameres, thus releasing the female genitalia, after which the pair separates. The female flies away first but only to very short distance and remains quiet. The male comes back to its normal position, and remains quiet. It may be added that when disturbed, a copulating pair cannot separate at once. The female flutters its wings about ten times and separates from the male with great difficulty. This is due to the fact that the vagina has a very small opening, so that the ædeagus and the ductus cannot easily come out of it ; thus it takes time for the muscles to relax and allow the two to separate.

The actual extent to which the ædeagus and its ductus ejaculatorius reach the common oviduct has not been determined. Pruthi (1925) stated : " Opinions differ as to whether the spermatozoa are put in any part of the oviduct whence they subsequently travel into the spermatheca, or whether they are conveyed directly to the latter organ in the first instance ". He further added : " In Homoptera the spermatheca is very near the uterus and the setiform ædeagus reaches the organ directly ". When the position of the spermatheca and the extent to which the ædeagus penetrates into the bursa at the time of copulation are studied (Figs 3 & 4), it becomes clear that the ædeagus cannot deposite the spermatozoa into the spermatheca. The spermatheca opens into the posterior region of the bursa copulatrix, while the ædeagus enters the anterior part of the bursa (Fig. 4). Further the shape and size of the spermatheca also confirm the view that the ædeagus does not enter the spermatheca. The structure and the position of the vagina into the bursa also indicate that the sperms are deposited directly into the vagina. Thus it can be safely concluded that the sprematozoa are not placed directly into the spermatheca

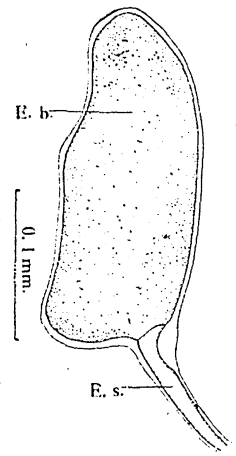


Fig. 5.—Egg with its stalk. *E. b.*, eggbody ; *E. s.*, eggstalk.

at least in *D. eugeniæ*, but that they are deposited into the vagina whence they travel subsequently into the spermatheca. In this species the bursa only acts as an intermediate organ for the passage of the spermatozoa from the vagina to spermatheca.

B. *Oviposition*

The eggs are laid on the under surface of the tender leaves of food-plant, in clusters arranged more or less in the form of circular bands. Each egg is very firmly fixed to the leaf by a stalk, so that wind or rain cannot detach it easily from the leaf. The eggs are smooth and shining and are oval in shape (Fig. 5). Each egg is about 0.21 mm. long and about 0.09 mm. thick, while the stalk is about 0.09 mm. in length. During egg-laying the female contracts its abdomen about five to six times and it looks as if the insect is trying to squeeze something out of its abdomen. I have not been able to observe the working of the ovi-positor as it is always hidden by wings.

V. A Comparative study of the genitalia of Aleurodidae

I have summarised below the characters of the genitalia in eleven species :—

(1) *Aleurodes schizuokensis* Kuwana (Fig. 6) :—Aedeagus 0.13 mm. long, 0.015 mm. thick, uniformly thickened throughout. Parameres 0.15 mm. long, 0.045 mm. thick, lobe-like structure. Posterior chitinous structure large, rhomboid in shape. Basal plates fused, long. Ductus ejaculatorius sac small ; duct thick and shining. Anal style small, cone-shaped ; 9th segment smaller than the 8th. ; 10th. segment small.

(2) *Aleurotulus maculata* Singh (Fig. 7) :—Aedeagus 0.12 mm. long, 0.05 mm. thick, one of its sides having curvature in the middle, distal end pipette-like. Parameres 0.13 mm. long, 0.035 mm. thick, consisting of two parts—handle and blade, former thick, latter spear-shaped. Posterior chitinous structure small. Basal plates small, completely fused.

(3) *Dialeurodes dissimilis* Q. & B. (Fig. 8) :—Aedeagus 0.095 mm. long, 0.012 mm. thick, elongated, its tip blunt. Parameres 0.13 mm. long, 0.03 mm. thick, elongated, lobe-like structure absent. Posterior chitinous structure vestigial. Basal plates small, completely fused. Ductus ejaculatorius sac large ;

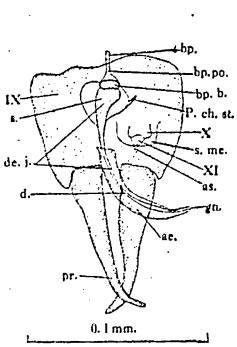


FIG. 14. *Aleurotuberculatus steriospermi*

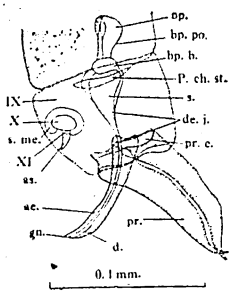


FIG. 10. *Dialeurodes pallida*

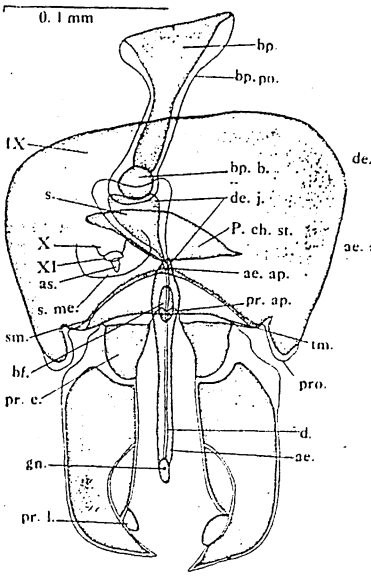


FIG. 6. *Aleurodes schizuokensis*

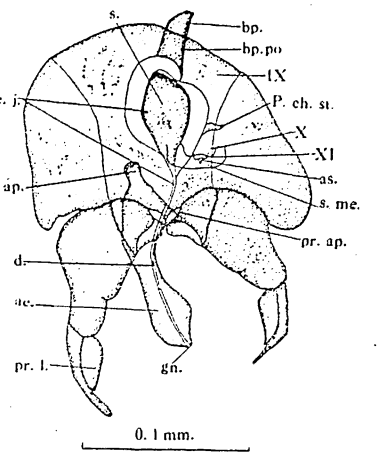


FIG 7 *Aleurodes maculata*

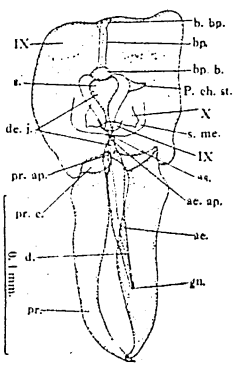


FIG. 9. *Dialeurodes kirkaldyi*

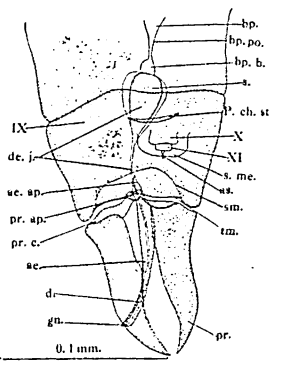


FIG. 11. *Aleurodiscus holmsii*

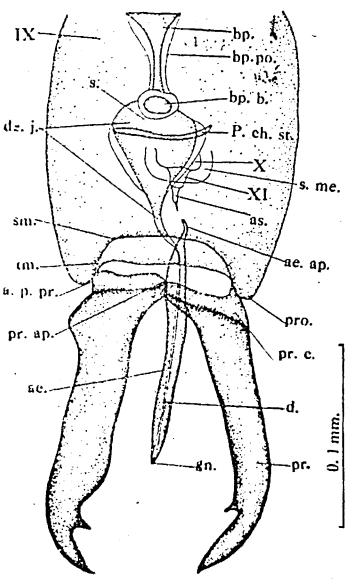


FIG. 12. *Trialeurodes bicolor*

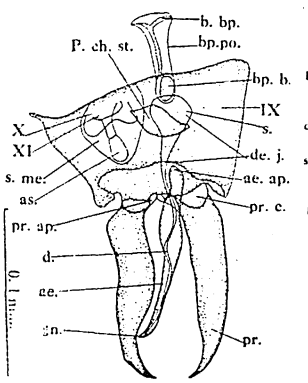


FIG. 13. *Trialeurodes ricini*

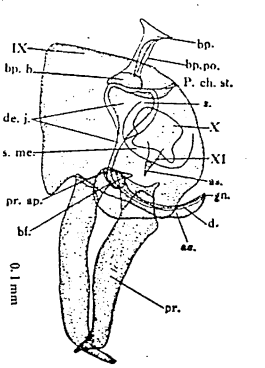


FIG. 8. *Dialeurodes dissimilis*

duct very thin. Anal style thick, small, cone-shaped; 9th. segment largest; 10th. fairly large.

(4) *D. kirkaldyi* Kot. (Fig. 9):—Aedeagus 0.07 mm. long, 0.012 mm. thick, its tip blunt, uniformly thick. Parameres 0.084 mm. long, 0.04 mm. thick, their tips pointed. 9th. segment smaller than 8th.

(5) *D. pallida* Singh (Fig. 10):—Aedeagus 0.15 mm. long, 0.012 mm. thick. Parameres 0.12 mm. long, 0.044 mm. thick, elongated. Posterior chitinous structure large, rhomboid in shape. Basal plates large. Anal style elongated, two segmented; 9th. segment largest.

(6) *Aleurodiscus holmsii* Maskell (Fig. 11):—Aedeagus 0.084 mm. long, 0.02 mm. thick, its tip pointed. Parameres 0.132 mm. long, 0.038 mm. thick, thin, uniformly thick, elongated. Posterior chitinous structure very small. Basal plates elongated.

(7) *Trialeurodes bicolor* Lamba (Fig. 12):—Aedeagus 0.13 mm. long, 0.016 mm. thick, elongated. Parameres 0.15 mm. long, 0.04 mm. thick, their tips pointed. Posterior chitinous structure small, strip-like.

(8) *T. ricini* Misra (Fig. 13):—Aedeagus 0.08 mm. long, 0.015 mm. thick, tapering. Parameres 0.1 mm. long, 0.02 mm. thick, flat, leaf-like. Posterior chitinous structure small.

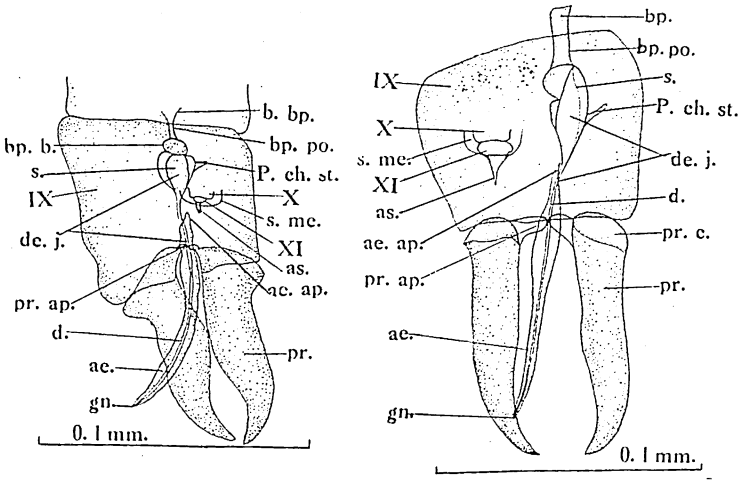
(9) *Aleurotuberculatus steriospermi* Corbett (Fig. 14):—Aedeagus 0.08 mm. long, 0.02 mm. thick, tip pointed. Parameres 0.109 mm. long, 0.024 mm. thick, elongated, tips pointed. Posterior chitinous structure very small. Basal plates small thick, completely fused.

(10) *Aleurodiscus burmiticus* Cockrell (Fig. 15):—Aedeagus 0.083 mm. long, 0.016 mm. thick, uniformly thick, elongated. Parameres 0.076 mm. long, 0.03 mm. thick, tips pointed, flat leaf-like. Posterior chitinous structure vestigial. Basal plates small. Anal style cone-shaped.

(11) *Aleurodes* sp. (Fig. 16):—Aedeagus 0.085 mm. long, 0.014 mm. thick, elongated, its tip pointed. Parameres 0.08 mm. long, 0.028 mm. thick, elongated, their tips pointed. Basal plates elongated. Anal style elongated, cone-shaped.

From the characters enumerated above, one can get a general idea of the genitalia in this family. Briefly, the chief points of interest are as follows :—

With a few exceptions the 9th. segment is the largest. It is sometimes produced into a pair of short lateral processes posteriorly, which are either conical or blunt. The 10th. segment is either large and well



Figs. 15 & 16.—Male genitalia of *Aleurodiscus burmiticus* and *Aleurodes* sp. Letterings as in fig. 1.

developed, or remains very small; only in some cases it shows a pair of lateral projections posteriorly. The anus is always situated on the 10th. segment. The 11th. segment is more or less conical and projects posteriorly. The anal style is well developed and is either conical or flagellum-like in shape. Both the 10th. and 11th. segment consist of a tergal plate only.

The ædeagus is generally very simple but in some species, *e.g.*, *Aleurotulus maculata*, it is complicated. The base is thick and cylindrical or conical in shape, but the apex is always pointed. The base developes an apodeme which is either solid, thick and highly chitinised or thin and ill-developed. The basal foramen is always well developed and about its middle the ductus ejaculatorius passes into the ædeagus. The gonopore is situated at the tip of the ædeagus.

The ductus ejaculatorius shows two conditions: in some species, *e.g.*, *D. eugeniæ*, the sac of the ductus ejaculatorius is small and the duct is stiff and shining and can be traced up to the very tip of the ædeagus, while in other species, *e.g.*, *D. dissimilis*, the sac is large and the duct is thin and delicate and is visible only in the proximal part of the ædeagus, although in newly hatched males it is clearly seen to reach the very tip of the ædeagus.

The parameres are smooth and flattened, either leaf-like or thin and elongated. They are thickest at the base, but their tip is always pointed and is sometimes provided with a lobe-like process. The plates meet in the middle line dorsally and form an apodeme for the attachment of the muscles. Small bristles are found all over the surface.

The basal plates are distinctly of two types : in some species, *e.g.*, *D. dissimilis*, the plates and their prolongation are small, but in other, *e.g.*, *D. engeniæ*, the basal plates and their prolongations are large. The plates are T-shaped, and their posterior parts show a circular area which appears like an opening due to incomplete chitinisation. The posterior chitinous structure is also of two types : in some species, *e.g.*, *D. dissimilis*, it is very small and more or less ribbon-shaped, while in others, *e.g.*, *D. engeniæ*, it is very large and more or less boat-shaped.

VI. Remarks on the classification and phylogeny of the family on the basis of the genitalia

Quaintance and Baker (1913) divided the family Aleurodidæ into three sub-families, namely, Aleurodicinæ, Aleyrodinæ, and Udamoselinæ on the basis of fore-wing venation and the shape of paronychium. Further, they based the classification of the sub-families into genera and species chiefly on the characters found in the pupa and pupal-case. They remarked (1914), "unfortunately Aleurodidæ are as yet largely known only from the pupa-stage, a condition due to their mode of life. A comprehensive classification based on the study of the adults would not, therefore, be possible for many years to come".

I have made a collection of adults of a large number of species of this family, but in most cases I was unable to find the pupa and the pupal-case. Further, I found that the pupæ and pupal-cases of the two sexes were so different that one may regard them as two different genera. Roonwal (1936) has also recorded a similar observation. I find that the genitalia afford a very satisfactory basis for the classification of the family. I would therefore suggest that the time for the classification of the family based on the adult characters rather than on the pupal characters has now arrived, and that genitalia should form an important set of diagnostic characters along with other characters to distinguish the different genera.

On the basis of the genitalia, the family can be divided into two groups, A and B, which are distinguished as follows :—

Parts of the Genitalia.	Group A.	Group B.
Aedeagus.	Phallic-apodeme solid, thick, highly chitinised.	Phallic-apodeme thin and ill-developed.
Parameres.	Flattened, leaf-like.	Thin and elongated.
Ductus ejaculatorius.	Sac of the ductus small, duct stiff and shining, can be traced upto the very tip of the ædeagus.	Sac of the ductus big, duct thin and delicate, and traceable upto the very tip of the ædeagus.
Basal plates.	Basal plate and its prolongation is large.	Basal plate and its prolongation small.
Posterior chitinous structure.	Very large and more or less boat-shaped.	Very small and more or less ribbon-shaped.
9th. segment.	Smaller than the 8th. segment.	Bigger than the 8th. segment.
10th. segment.	Small and not well developed.	Large and well developed.

The various species of Aleurodidæ studied fall into the two groups as given below:—

GROUP A.

1. *Dialeurodes eugeniæ.*
2. *Aleurodes schizuokensis.*
3. *Aleurotulus maculata.*

GROUP B.

1. *Dialeurodes dissimilis.*
2. *D. kirkaldyi.*
3. *D. pallida.*
4. *Aleurodiscus holmsii.*
5. *Trialeurodes bicolor.*
6. *T. ricini.*
7. *Aleurotuberculatus steriospermi.*
8. *Aleurodiscus burmiticus.*
9. *Aleurodes* sp.

Quaintance and Baker (1913) while reviewing the systematic position of Aleurodidæ state that " it appears to us from a careful study of different forms that the Aleurodidæ are not intermediate in position between the Aphididæ and Coccidæ but they form an offshoot from the Psyllid stem. This is indicated by the wing venation and by the structure of the mouth-parts, legs and genitalia ". As regards the evidence from the genitalia they remark: " from the extremity of which (vasiform orifice) protrudes the claspers (parameres) and the copulatory organ. It does not seem impossible that the last segment represents the sub-genital plate and has been produced by the fusion of the upper margins of that plate, while the lingula represents the supra-anal plate ". Again they state, " the penis (ædeagus) is carried recurved towards the vasiform orifice in a manner very similar to that found in the Psyllidæ".

Unfortunately the above observations are at varience with those made by the writer. I believe that they have come to erroneous conclusions

about the structure of genitalia in Psyllidæ with which they closely relate the Aleurodidæ. In fact, there is no vasiform orifice in the adult Aleurodidæ. They are also mistaken in regarding the 9th, 10th, and 11th segments as sub-genital plate, vasiform orifice, and supra-anal plate respectively. During the course of my study of the development of the male genitalia I found that the 9th segment (sub-genital plate of Quaintance and Baker) is never produced by the fusion of two plates, but it is formed as a complete segment, like the other segments of the body. Therefore it can safely be said that their conclusion regarding the presence of sub-genital plates is erroneous. The recurving of the penis is never found in the normal condition but only at the time of copulation ; only when the male is in an excited condition, a little recurving of the penis does take place. This view is further supported by the diagrams of genitalia appended by them, because in most of their illustrations they do not show the recurving of the penis ; in the few cases in which recurving is shown specimens were perhaps fixed when they were in an excited condition and ready for copulation.

In view of the foregoing it is safe to conclude that on the basis of genitalia the family Aleurodidæ is not closely related to the Psyllidæ. It may be nearer Psyllidæ than other families of Sternorhyncha, but if it is compared with all the families of the sub-order Homoptera, the family is most closely related to Cicadidæ. In fact, the genitalia of the family Aleurodidæ are very similar to those regarded by Muir (1930) as the normal Cicadodian type.

Pruthi (1925) stated : " The division of the sub-order Homoptera into Sternorhyncha and Auchenorhyncha is not supported by the structures of the genitalia ". I confirm Pruthi's view because my study of the male genitalia shows that the family Aleurodidæ (Sternorhyncha) resembles the family Cicadidæ (Auchenorhyncha) more than it does any other family of Sternorhyncha. The family Coccidæ (Sternorhyncha) also resembles the family Cicadidæ (Auchenorhyncha) most, as Pruthi (1925) has already shown. As regards the family Psyllidæ, Pruthi (1925) is of the opinion that it resembles the family Fulgoridídæ, while Muir contends that it resembles the family Cicadidæ. Whichever view may be correct, it is certain that the family Psyllidæ resembles the Auchenorhyncha group much more closely than the Sternorhyncha.

The division Sternorhyncha contains only four families, out of which the genitalia of the family Aphididæ have not been studied so far, while the remaining three families, *i.e.*, Psyllidæ, Coccidæ, and Aleurodidæ, resemble the division Auchenorhyncha much more than they do one another. Thus it may be concluded that the division of the sub-order Homoptera into Sternorhyncha and Auchenorhyncha does not hold good on the basis of the genitalia, as was pointed out by Pruthi (*op.cit*) about fifteen years ago.

VII. Acknowledgments

I wish to record my thanks to Prof. K. N. Bahl, whose direct supervision, helpful criticism and painstaking correction of the manuscripts have been very helpful in this investigation, I am indebted to Dr. Hem Singh Pruthi, Imperial Entomologist, Government of India, for his valuable criticism. I am grateful to Dr. M. L. Bhatia, Lecturer in Zoology, for his kind help in various ways. My thanks are also due to the University of Lucknow for the grant of a Research-fellowship.

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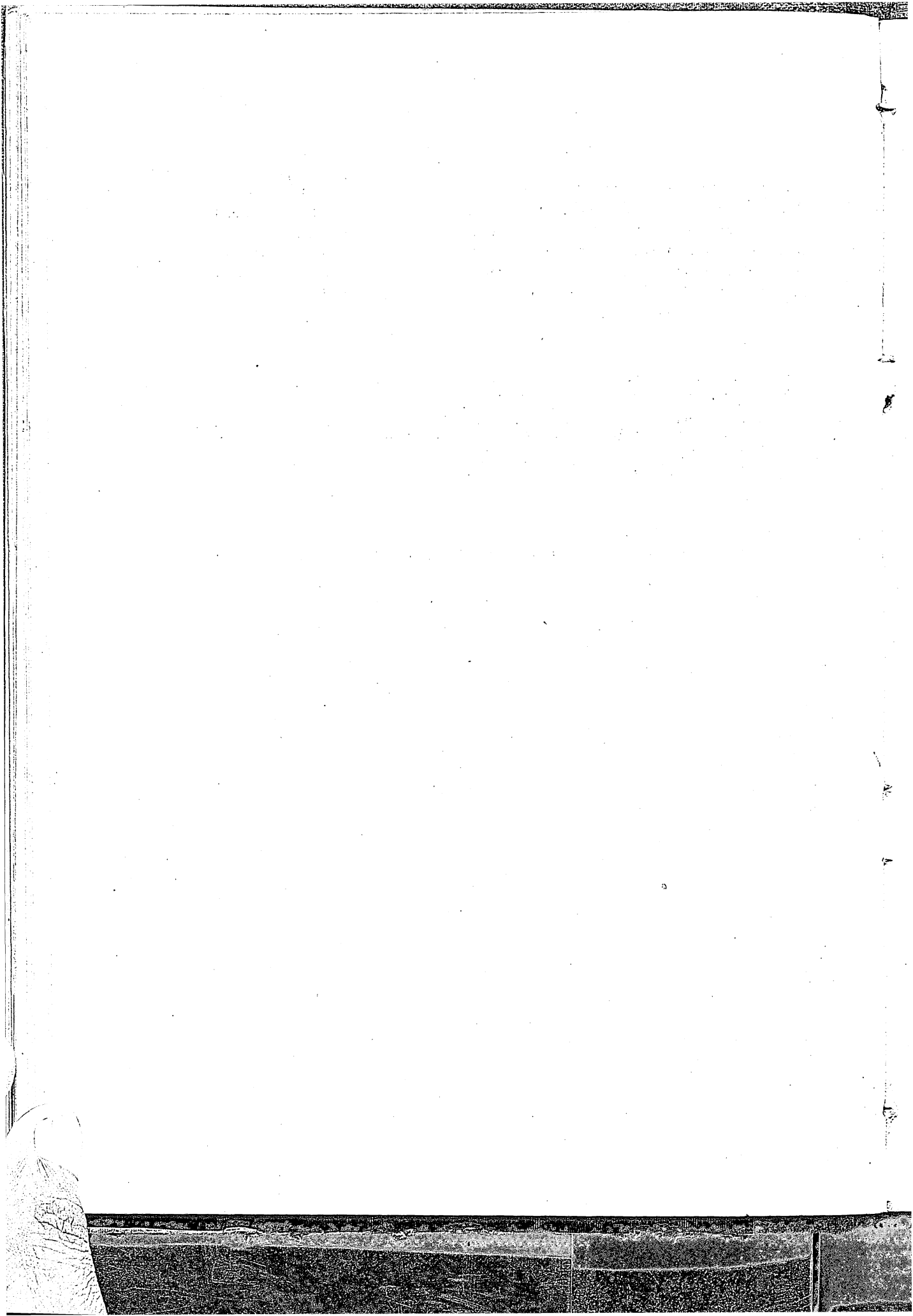

STUDIES ON *PLATYEDRA GOSSYPIELLA* SAUNDERS IN THE PUNJAB

PART IV.* RELATIVE INCIDENCE ON EXOTIC AND INDIGENOUS VARIETIES OF COTTON

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and

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CONTENTS

INTRODUCTION

Several investigators have found that the incidence of pink bollworm (*Platyedra gossypiella*) is higher on certain types of cottons than on others. Fletcher (1914, 1917), Mackerrel (1924), and Hilson (1925), working in different parts of India, have stated that the attack of this pest is more serious on the exotic (American) varieties than on the indigenous ones. In fact, the first record of the occurrence of pink bollworm in India (from Bombay in 1843) was from the introduced American varieties (Durrant, 1912). Outside India, Wolcott (1927 and 1928) has found that this pest in Haiti attacks the Sea Island cotton more than it does the indigenous types, and Bishara (1930) has shown that in Egypt Sakel variety is attacked more than the Zagora.

This varietal discrimination is so marked that Harland (1929) has made the suggestion that the American cottons be used as 'trap crop' for the control of pink bollworm in the Old World cottons, and Sampson (1934) has set forth the proposition that one possible method of safeguarding against pink bollworm may be the evolution of a resistant Asiatic variety.

The present investigation was undertaken to study the comparative infestation of pink bollworm on the chief indigenous and exotic varieties of cotton grown in the Punjab. The scheme of research was financed by

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II. COTTON GROWING IN THE PUNJAB

A general account of cotton growing in the Punjab is given by Milne (1920), Trought (1928), and Milne and Ali Mohammad (1933). Cotton is grown in the plains throughout the province. The total area under this crop, on an average of 10 years (1924-25 to 1933-34) has been 2.26 million acres, of which 2.10 million acres, or over 90 per cent, was canal irrigated. The types sown are mostly the strains of *Gossypium indicum*, *G. neglectum* and *G. sanguineum*, from among the indigenous, and 4F. and 289 F. strains of *Gossypium hirsutum*, from among the exotic. The area under the indigenous varieties, on an average, has been one and a half times as much as under the exotic.

In the South Eastern, submontane and Central Punjab, where pink bollworm is a serious pest, mainly the indigenous varieties are grown, while in the Canal Colonies and the Western Punjab, where this pest is negligible (Bindra, 1928), both the indigenous and exotic varieties are grown.

The observations recorded in this paper were made, unless otherwise stated, on *G. hirsutum* var. 4 F., and *Gossypium indicum* var. *mollisoni*, and rarely on *G. neglectum*.

III. METHODS OF INVESTIGATION

The incidence of pink bollworm was studied from the examination of green bolls. Each sample usually consisted of two hundred bolls, and was collected from the *desi* (indigenous) and American cottons growing in adjacent fields. The bolls were collected from as many plants as possible and mostly those which were more than a week old were taken.

In 1931, only stray observations were made and green bolls were collected from the neighbourhood of Lyallpur only. In 1932, the incidence of the pest was studied at Ferozepur, Gujranwala, Sargodha, Lyallpur, Montgomery and Multan. At each of these centres adjacent plots under *desi* and American cottons were selected, and green bolls were examined from the time when they were found up to the beginning of December. In 1933, these observations were confined to Ferozepur, Gujranwala and Lyallpur. At Lyallpur two *desi* varieties, namely, *Gossypium indicum* var. *mollisoni* and *Gossypium sanguineum*, and three American

varieties, namely, *Gossypium hirsutum* 4 F., 43 F., and 289 F., were grown side by side and the incidence of the pest studied throughout the season.

Besides these observations, two mosquito-netting cages were put up at Lyallpur in 1932 on the *desi* and American cotton plants growing side by side. One of these cages (A) enclosed five plants of *mollisoni* and three of 43 F. while the other cage (B) enclosed seven plants of the former and five of the latter. Seven pairs of bollworm moths, which had copulated during the previous night, were liberated in cage A on 10th August, while in cage B eight such pairs were liberated on 14th August. Cage A was removed two months after the liberation of moths, *i.e.*, on 9th October, and all the buds and bolls were removed from the plants of the two varieties separately and examined. Similarly, cage B was removed on 19th October and all the buds and bolls present were collected and examined from the different varieties.

In 1933, only one cage C was set up at Lyallpur which enclosed six plants of *mollisoni* and four of 4 F. and eight pairs of moths were liberated on 15th August. This cage was opened on 1st December, 1933 and all the buds and bolls from the two varieties were collected separately and examined.

IV. Discussion of the data

Table I gives the percentage of green bolls attacked* at different times during 1931 in the suburbs of Lyallpur.

A study of these results shows that with the exception of one case (13.XI.), where the attack was 2% in the American, and 3% in the *desi*, the American cottons invariably showed a higher incidence of bollworm than the *desi* cottons. Not only was the incidence on the American cotton high, but the difference in the intensity of attack on the two cottons was often very marked. For instance, the second sample of 13th November showed 36% attack on the American as against 4% on the *desi*. In the same field later in the season (on 26.XI.) the American cotton showed 38% attack, the highest recorded from Lyallpur during the year, while the *desi* cotton showed 8% only.

* Besides giving the percentage of green bolls attacked, it has been thought advisable to give in this and all subsequent Tables the number of larvæ found in 100 green bolls. In text, however, with some exceptions we have discussed only the percentage of green bolls attacked. The reason for doing so is that there is definite correlation between the percentage of green bolls attacked and the number of larvæ found in 100 bolls.

TABLE I. *Incidence of pink bollworm on desi and American cottons at Lyallpur* (1931) *and at Gujranwala and Ferozepur* (1933).

(The incidence is indicated by the ratio, between percentage green bolls attacked and number of larvæ per 100 green bolls).

Date of examination	Incidence on		Date of examination	Incidence on	
	desi	American		desi	American
I. at Lyallpur (Agric. College)			*III. at Gujranwala*		
15.X	0:0	1:1	21.IX	13:14	13:13
23.X	2:2	12:12	1.X	19:20	35:51
31.X	8:8	13:15	11.X	36:40	59:115
7.XI	4:4	12:14	21.X	58:96	85:228
17.XI	6:6	12:14	1.XI	64:108	93:270
25.XI	5:5	8:9	21.XI	62:109	86:267
II. at Lyallpur (suburb)					
6.XI	0:0	5:5			
13.XI	3:3	2:2	*IV. at Ferozepur*		
13.XI	4:4	36:56	21.IX	3:4	12:14
26.XI †	19:24	25:33	1.X	5:6	13:15
26.XI ‡	9:9	23:30	11.X	7:7	14:15
26.XI	8:8	38:52	21.X	21:31	24:34
27.XI	2:2	4:4	1.XI	41:60	39:62

† *Desi* cotton surrounding the American.
‡ American cotton surrounding the *desi*.

Of special interest are the data obtained from the experimental plots of the Cotton Research Botanist at the Agricultural College, Lyallpur, where samples were collected, in one case, from the *desi* cotton fields surrounding an American field, and in another case from the American cotton fields surrounding a *desi* field (Table I). In the first case, in spite of being surrounded by the *desi* on all sides, the attack on the American was higher than on the *desi*, *i.e.*, 25% as against 19%, while in the other case the attack on the American was much higher than on the *desi*, 23% as against 9% of the latter. The probable explanation is that in the latter case bollworm moths coming from outside settled on the American cotton and only a few of them penetrated to the *desi* cotton field inside; while in the former case they travelled in large numbers to the American cotton in spite of the

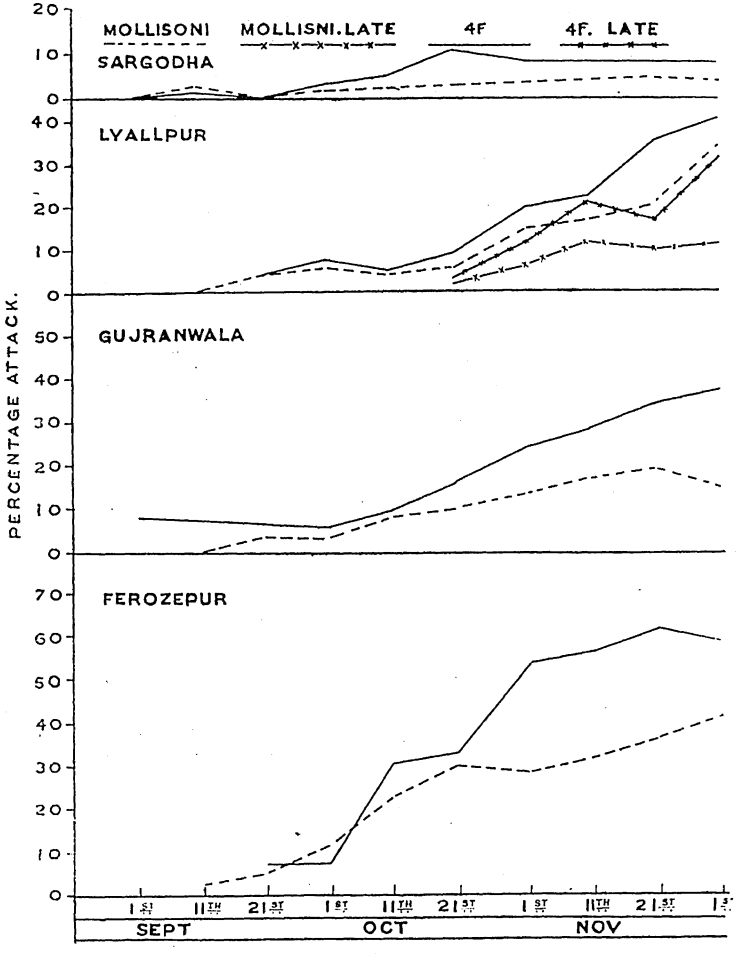

Fig. 1.

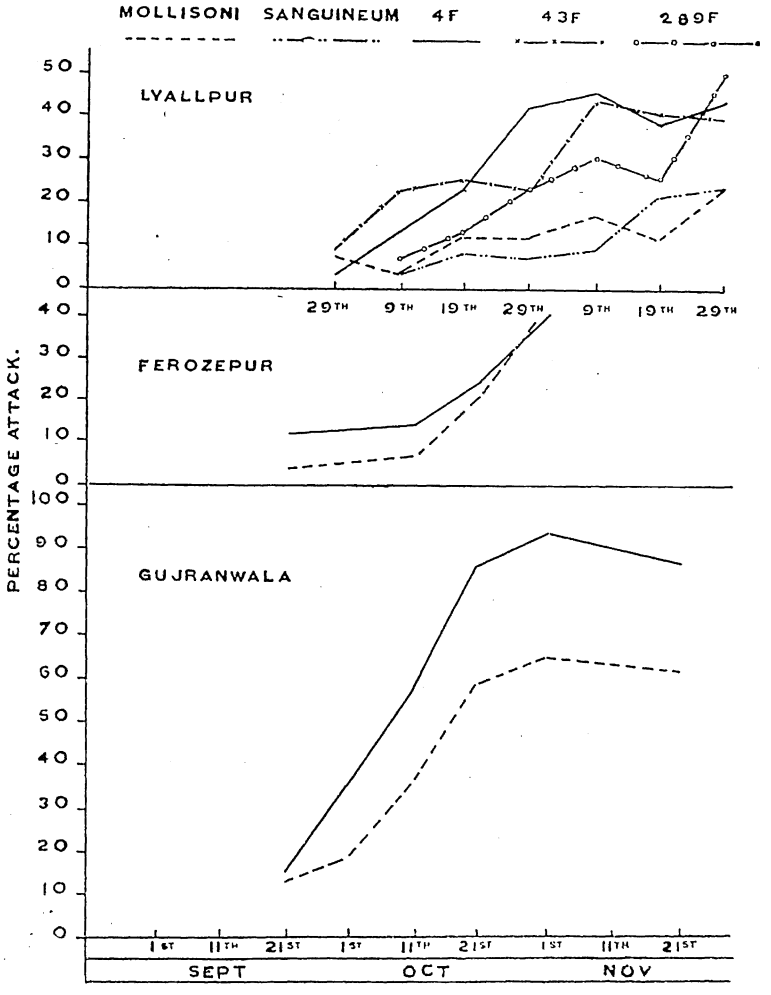

Fig. 2.

Graphs showing relative intensity of attack on *desi* and American cottons at different localities in 1932 (Fig. 1.) and 1933 (Fig. 2.)

abundance of available food on the *desi* cotton growing all round, thus showing their decided preference.

Table II gives the result of boll examination at six different stations during 1932 and Fig. 1 * is a graphic representation of these results.

A study of Table II and Fig. 1 shows that the attack in green bolls increases with the progress of the season and that the intensity of attack varies at different stations. Thus at Ferozepur, which showed the highest incidence of the bollworm, the attack rose from 7% on the American cotton on 21st September to 59% on 1st December, while on the *desi* cotton it rose from 6 to 42% during the same period. At Gujranwala, which showed the next highest incidence, the attack rose from 8% on 1st September to 39% on 1st December on the American, and from nil to 16% on the *desi*. At Sargodha and Lyallpur the attack rose gradually from the time green bolls were available up to 1st of December, while at Montgomery and Multan there was practically no attack, the highest reached being only 3% and that too late in the season.

Further, it will be observed from Table II and Fig. 1, that all through the cotton season, except in a few cases in the beginning of the season, the attack was always higher on the American cotton, than on the *desi*. It is also apparent that, generally, when the incidence is low the difference in attack between these two types of cottons is very little, but with a rise in incidence this difference becomes more and more marked.

Table I also gives the incidence of the bollworm attack at Gujranwala and Ferozepur in 1933. A study of this Table and Fig. 2 shows that the attack on the American cotton both at Gujranwala and Ferozepur was, except once at the latter station, again higher than that on the *desi* cotton. Further, it will be observed that the attack at Ferozepur in 1933 rose from 12 to 39% on the American and from 3 to 41% on the *desi* and was generally lower than that in 1932 (Table II) on both the cottons. At Gujranwala, on the other hand, the attack rose from 13 to 86% on the American and from 13 to 62% on the *desi* and was higher than that in 1932. Again, while Ferozepur showed higher attack than Gujranwala in 1932, it was just the reverse in 1933. No attempt has been made in this paper to explain such fluctuations but these are most probably the results of climatic variations.

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* The attack was negligible at Montgomery and Multan and hence has not been shown in this figure.

TABLE II. *Incidence of pink bollworm (ratio between percentage of green bolls attacked and no. of larvæ in* 100 *green bolls) on* desi (*D*) *and American* (*A*) *cotton varieties at different localities in* 1932.

Locality	Variety	Incidence on different dates									
		1.IX.	11.IX.	21.IX.	1.X.	11.X.	21.X.	1.XI.	11.XI.	21.XI.	1.XII.
Gujranwala	D.	0:0	0:0	4:5	4:4	9:9	11:13	14:16	18:23	21:24	16:19
	A.	8:8	8:8	7:7	6:7	10:14	17:20	25:32	30:39	35:47	39:62
Ferozepur	D.	—	3:3	6:7	13:14	24:28	30:35	29:42	33:43	37:63	42:70
	A.	—	—	7:10	8:10	31:42	33:41	54:77	57:100	63:102	59:107
Sargodha	D.	0:0	2:2	1:1	2:2	2:2	3:3	3:3	4:4	5:5	4:5
	A.	1:1	1:1	0:0	4:4	5:7	11:12	8:9	8:10	9:11	9:9
Lyallpur	D.	—	1:1	5:5	6:6	4:4	5:5	14:15	17:22	20:26	35:44
	A.	—	—	4:6	7:8	5:5	9:9	19:22	22:29	35:51	41:59
Lyallpur (late sown)	D.	—	—	—	—	—	1:1	7:7	12:14	10:12	12:16
	A.	—	—	—	—	—	2:2	10:11	21:27	18:26	32:42
Multan	D.	—	0:0	0:0	0:0	0:0	1:1	0:0	1:1	1:1	0:0
	A.	—	—	0:0	0:0	1:1	1:1	0:0	3:6	1:2	1:1
Montgomery	D.	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
	A.	—	—	0:0	0:0	0:0	0:0	1:1	0:0	1:1	2:2

Table III (varietal experiments) shows that, at Lyallpur, the attack on all the three exotic varieties grown under similar conditions was much higher than on the indigenous varieties. Thus on 43 F., the attack rose from 9 to 39%, on 4 F. from 3 to 44% and on 289 F. from 7 to 50%, while on *mollisoni* it rose from 7 to 25% and on *sanguineum* from 3 to 24%. Expressed in terms of averages for the whole season, 4 F. and 43 F. with 29% showed the highest attack, while in 289 F. the attack was 24% and in *mollisoni* and *sanguineum* only 12%.

To check the results of the last examination one sample of each of the three above mentioned American varieties and *mollisoni* was obtained on 14th October from the three "Sowing Date Experiments" of the Cotton Research Botanist (Table III). Here also the *desi* (*mollisoni*) cotton showed the lowest attack (11 to 16%). Among the American cottons the attack on 289 F. varied between 12 and 30% and was once again lower than in the other two varieties, while on 43 F. the attack varied between 15 and 39% and on 4 F. between 27 and 45%.

TABLE III. *Incidence of pink bollworm (ratio between percentage of green bolls attacked and no. of larvæ per* 100 *green bolls) on different varieties of cotton, at Lyallpur in* 1933.

Date of examination	Incidence on different varieties				
	Sanguineum	Mollisoni	43 F	4 F	289 F
			I. Varietal experiments		
29. IX	—	7 : 7	9 : 9	3 : 4	—
9. X	3 : 3	3 : 3	23 : 27	13 : 17	7 : 9
19. X	9 : 9	12 : 17	25 : 33	23 : 27	12 : 17
29. X	7 : 9	12 : 13	23 : 28	42 : 70	23 : 30
9. XI	9 : 10	17 : 22	44 : 73	44 : 68	30 : 44
19. XI	21 : 25	12 : 14	40 : 71	37 : 64	24 : 40
29. XI	24 : 32	25 : 29	39 : 78	44 : 67	50 : 72
			II. Sowing date experiments		
14. X	Early sown	13 : 15	39 : 53	45 : 65	30 : 47
,,	Normal sown	16 : 17	38 : 58	30 : 39	23 : 31
,,	Late sown	11 : 12	15 : 19	27 : 34	12 : 12

Further, it will be observed from Table III (sowing date experiments) that in the middle of November the early sown cottons, with the exception of *mollisoni*, showed higher attack than those sown at the normal time and the latter without exception higher attack than those sown late. It will not be safe, however, to conclude from these results that the early sown cottons suffer more than the late sown. What seems more probable is that the early sown cottons, because of their early fruiting attract a large number of moths in the beginning of the season and thus show higher attack, but as these cottons mature early they escape prolonged damage which the late sown cottons suffer. In Egypt it has been found that the late maturing varieties suffer much more than the early maturing varieties and hence the production of early maturing varieties has been advocated as a check against pink bollworm by almost all workers (Willcocks 1916, Ballou 1920, Storey 1921, Williams 1924). In those parts of the Punjab, where the pest is serious, experience also indicates a higher attack on the cottons maturing late.

Table IV gives the incidence of bollworm on 43 F. and *mollisoni* grown under cages in 1932. Cage A enclosed three plants of 43 F. and when it was removed there were 90 green and 7 open bolls on these plants. Out of these 40 green bolls were attacked and had 69 caterpillars, while of the open bolls only 2 were attacked and each had a single caterpillar. The attack on the green and open bolls taken together was thus 43.3% and the number of caterpillars per 100 bolls 75.5. The five *mollisoni* plants enclosed in the same cage had, on the other hand, 105 green bolls and 36 open bolls. Of these only 12 green bolls were attacked

and had 15 caterpillars, while of the open bolls 8 were attacked and each one had a single caterpillar. The attack on open and green bolls taken together thus comes to only 14.2%, and the number of caterpillars per 100 bolls 16.3 (see Fig. 3).

In cage B there were 84 green bolls and 10 open bolls on 43 F. plants, out of which 64 of the former were attacked and had 138 caterpillars, while of the latter only 6 were attacked and had 8 caterpillars. The percentage attack on the open and green bolls taken together was thus 74.5 and the number of caterpillars per 100 bolls 155.3. Of the *mollisoni* plants enclosed in the same cage, there were 140 green bolls, 55 open bolls and 58 buds. Out of these 44 green bolls, 20 open bolls and 8 buds were attacked and had 60, 30 and 8 caterpillars respectively. The attack on the green and open bolls taken together was 34.4%, and the number of caterpillars per 100 bolls 47.7.

It may be stated that 43 F. was selected from the American varieties because it matures early and the progress of its flowering and bolling is very much like that of the *desi* var. *mollisoni*.

Table IV also gives the incidence of the bollworm on 4 F. and *mollisoni* plants enclosed in the same cage in 1933. When the cage was removed there were 150 green and 26 open bolls on 4 F. plants. Out of these 70 green and 13 open bolls had been attacked and had 111 and 15 caterpillars

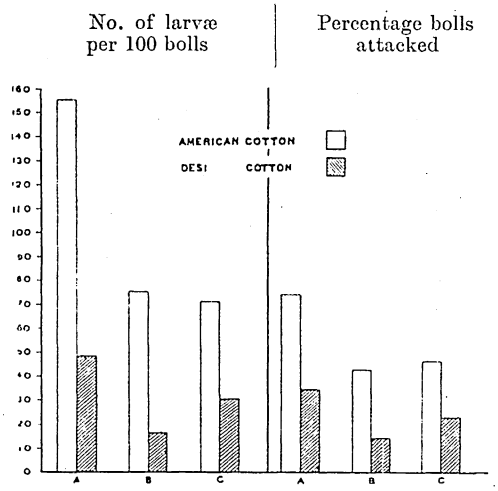

Fig. 3. Relative intensity of attack in different cages.

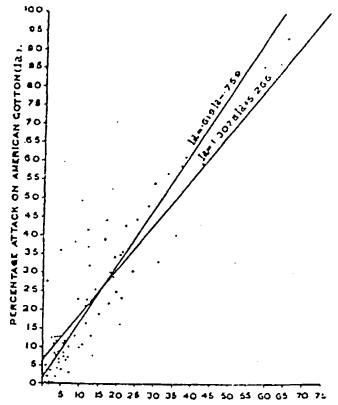

Fig. 4. Scatter diagram and regression lines showing percentage attack on *desi* cotton (I d).

respectively. On the *mollisoni* plants enclosed in this cage, there were 102 green and 80 open bolls and of these only 25 of the former had been attacked and had 39 caterpillars, while of the latter 21 were found infested and had 27

TABLE IV. *Incidence of pink bollworm on* desi *and American Cottons in cages during* 1932-1933

Year under observation	Cage No.	Variety of cotton	No. of plants	Ratio between total no. of buds and no. attacked	Ratio between percentage of buds attacked and no. of larvæ per 100 buds	Ratio between total no. of green bolls and no. attacked	Ratio between percentage of green bolls attacked and no. of larvæ per 100 bolls	Ratio between total no. of open bolls and no. attacked	Ratio between percentage of open bolls attacked and no. of larvæ per 100 bolls
1932	A	43 F.	3	—	—	90/40	44.4/76.7	7/2	28.6/28.6
	,,	Mollisoni	5	—	—	105/12	11.4/14.3	36/8	22.2/22.2
	B	43 F.	4	—	—	84/64	76.2/164.3	10/6	60.0/80.0
	,,	Mollisoni	7	58/8	13.9/13.9	140/44	31.4/42.9	55/23	41.8/60.0
1933	C	4 F.	4	—	—	150/70	46.7/74.0	26/13	50.0/57.7
	,,	Mollisoni	6	—	—	120/25	20.8/28.3	80/21	26.3/33.8

caterpillars. The attack on both the green and open bolls of 4 F. was thus 47.2% and the number of caterpillars per 100 bolls 71.6, while on the *mollisoni* the attack on bolls was only 23%, and the number of caterpillars per 100 bolls 30.5.

V. General discussion

The data presented above show that the incidence of pink bollworm is higher on the American cottons than on the *desis*, grown under similar conditions.

An attempt has been made to find out the relationship between the incidence on *desi* (*mollisoni*) and American (4 F.) cottons. The data collected were examined statistically and a scatter diagram (Fig. 4) and correlation table prepared from the observations made on different dates and at different centres.

The calculated coefficient of correlation (r) comes to 0.8995, showing a highly significant correlation between the two types of cottons. The relation between the two as studied by Blakeman's Criterion (Blakeman, 1905) and Fisher's method of analysis of variance (Fisher, 1934) is significantly linear.

The regression lines are :—

$$Ia = 1.3078\ Id + 5.266$$

and $$Id = 0.619\ Ia - 0.759$$

Where Ia=percentage attack of bollworm on American cotton, and Id=percentage attack on *desi* cotton.

These regression lines (Fig. 4) enable one to predict the probable percentage attack of the bollworm on *desi* cotton for a particular percentage attack on the American cotton and *vice versa*. The above equations also indicate that (*i*) if Ia is the dependent variable for unit percentage increase in the attack of bollworms on *desi* cotton, the average percentage increase on American cotton is 1.3078, (*ii*) if Id is the dependent variable, the average percentage increase in the attack on *desi* cotton for unit percentage increase on American cotton is 0.619.

The mean ratio between the percentage attack on American and *desi* cottons has also been worked and found to be statistically significant, *viz.* :—

$$\frac{Ia}{Id} = 2.1921 \pm 0.1247$$

Having shown a relationship between the percentage attack of this insect on the *desi* and American cottons, we turn to the main question : Why is the incidence of attack higher on the American cottons than on the *desis* ?

A correlation between the intensity of bollworm attack and the climate as affecting the biotic potential of this insect, has been suggested (Afzal Husain, Haroon Khan and Nazir Ahmad, 1935) and it would, therefore, seem probable, that the difference in the intensity of attack on different cottons may be the result of micro-climates influenced by the peculiar habitats of the plants. In this connection it is interesting to record that the American cottons, as compared to the *desis*, have broader leaves and their plants are shorter in size and more spreading. This would mean more shade and therefore a slightly different climate prevailing in the American cotton fields. That shade influences the increase of bollworm has already been alluded to by Bishara (1930) and Knight (1935). Bishara in recommending an ideal variety for reducing attack of this pest in Egypt has (besides giving other characters) stated that it should give as little shade as possible, for rank growth means more insect damage. Knight in studying the effect of cloudy weather on bud and boll formation on American cotton in Sudan has found that artificial shading considerably increases the incidence of this pest. It may be suggested that perhaps the influence of shade is not direct but indirect affecting temperature and humidity. Uvarov (1931) has given several instances of the influence of different microclimates on the increase of insects in the same manner as suggested above. Recently Kirkpatrick (1937) has similarly shown the influence of microclimate on the abundance of the coffee bug in East Africa.

However, the cage experiments performed by us indicate that besides microclimate, the varietal susceptibility is also responsible for variation in incidence and that under similar microclimatic conditions the American and *desi* types could offer different degrees of resistance to insect attack.

In all the three cages set up in 1932 and 1933, there were only a few plants of American and *desi* cottons enclosed in each cage (Table IV). It would seem probable that the microclimate prevailing round both types of cottons was similar, and if microclimate was the dominating factor then the incidence of the pest should have been equal or about equal on both types of cottons, but it was not so.

If varietal susceptibility is a positive factor then is it the differential egg laying, hatching, or entrance of caterpillars into the bolls that brings about the difference in incidence or is it something else? There is one other factor which may perhaps be of importance. If the attacked buds and bolls of the *desis* are shed more easily than those of the Americans, then a large number of caterpillars, which have entered the bolls may be lost in the case of the *desis*, thus offering effective resistance to the biotic potential of the pest (Afzal Husain, 1926). Whatever may be the factors

determining these differences, the importance of the problem demands a most careful study from several aspects.

VI. Summary

The incidence of pink bollworm on the American and *desi* (indigenous) cottons was studied during 1931-1933.

The results obtained show that grown under similar conditions the American cottons are attacked more than the *desis*.

A relationship between the percentage attack of this pest on American (4 F.) and *desi* (*mollisoni*) cottons has been shown.

The incidence may be the result of different microclimates or varietal susceptibility, which may be expressed by the dropping down of attacked bolls, meaning death of more caterpillars.

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ON THE BIOLOGY OF *EUDERUS LIVIDUS* (*Ashm.*), A PARASITE OF *AGROMYZA OBTUSA* MALL.

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In the case of *Cajanus cajan*, one of the important pulses of India, soon after seed-formation the pods are attacked by the fly, *Agromyza obtusa* Malloch, which lays its eggs inside the pods containing young seeds. The maggots feed on the developing grains and sometimes as many as 63% grains are estimated to be thus destroyed (Ahmad, 1938). In nature, the larval stage of the fly is parasitized by the Chalcid, *Euderus lividus* (Ashmead) to a sufficiently large extent and, therefore, a detailed study of the biology and morphology of the parasite has been made, the results of which are summarized in the following pages.

I wish to thank Mr. M. S. Mani, Assistant to the Imperial Entomologist, for the identification of the parasite.

DISTRIBUTION AND HOSTS OF THE PARASITE

This is the first record of *E. lividus* from India. It was originally described as *Chrysocharis livida* by Ashmead in 1894. It is an important parasite of the coffee leaf miner, *Leucoptera coffeella* Guer., in Porto Rico (U. S. A.) where it causes at least 30% mortality of the host larvæ. It has also been found on the same host in Venezuela (South America) in 1927. *A. obtusa* is being recorded here for the first time as the host of this species although several other species of *Agromyza* are known to be attacked by parasites closely allied to *E. lividus*, e.g., *Agromyza pusilla* by *Chrysocharis ainsliei* and *C. parksi*; *A. felti* by *C. mallochi*, and *Agromyza* sp. by *C. elongatus*.

In India, larvæ of a "tur-pod fly" were reported to be attacked by a Chalcid parasite as early as 1910 from Nagpur (C. P.) and again from Cinnamara (Assam) in 1917. The specimens of these parasites are not available, but from the rough description of the parasite on record in the laboratory of the Imperial Entomologist, it seems that the parasite then reported was the same as the one now under report. During the last few years, I have bred this parasite from larvæ of *Agromyza obtusa* collected from Pusa (Bihar) in 1936, Karnal (Punjab) in 1937 and New Delhi in 1938. Thus it seems that the parasite is almost as wide-spread in India as its host.

SYSTEMATIC POSITION AND DESCRIPTION OF THE PARASITE

The genus *Euderus* is included in the family Eulophidæ, and about a dozen species of this genus have been described so far. The only two Indian species of it are *Euderus gossypii* Ferr. and *Euderus pempheriphila* Ramakr. & Mani, found parasitising the grubs of *Sphenoptera gossypii* Kerr. and *Pempheres affinis* Fst. respectively. As already stated *E. lividus* was described by Ashmead from America under the genus *Chrysocharis*. Girault (1924) redescribed and transferred it to *Euderus*.

The adults of this parasite not only present marked sexual dimorphism but even the individual sexes, particularly the males, exhibit great variation in size and colouration. This fact at first led the writer to state that there were two or three different species of the family Eulophidæ that were involved in this parasitism (*Indian J. agric. Sci.*, **3** : 74). But on further examination it has been found that they are merely sexual and size variations of the same species. These variations in the two sexes and in the same sex will be appreciated from an examination of the measurements of adults given in Table I below, and of figures 5 & 6, Plate III.

TABLE I. *Size variation in adults of* E. lividus (*Ashm.*)

MALES		FEMALES	
No. of individuals in a category	Length (mm.)	No. of individuals in a category	Length (mm.)
1	1.40 — 1.49	1	2.20 — 2.29
3	1.50 — 1.59	1	2.30 — 2.39
1	1.60 — 1.69	0	2.40 — 2.49
1	1.70 — 1.79	3	2.50 — 2.59
0	1.80 — 1.89	0	2.60 — 2.69
2	1.90 — 1.99	3	2.70 — 2.79
4	2.00 — 2.09	1	2.80 — 2.89
3	2.10 — 2.19	1	2.90 — 2.99
1	2.20 — 2.29	3	3.00 — 3.09
		0	3.10 — 3.19
		2	3.20 — 3.29
TOTAL :—16		TOTAL :—15	

It will be noticed that the majority of the females range in length from 2.5 to 3.0 mm., the longest of them being 3.25 mm. The males on the other hand fall in two well-defined categories. The larger males (Plate III, Fig. 5) measure 1.9 to 2.2 mm. and the smaller ones (Plate III, Fig. 6), which are proportionately less common, measure 1.45 to 1.6 mm. It seems that the undersized individuals of both sexes are produced under adverse conditions, such as poor quality or quantity of food, which may be due to competition among a number of parasite grubs feeding on the

same host larva, or other factors. Such specimens were not uncommon among the parasites collected from the field.

Besides size variation, there is considerable amount of variation in colour ; for example, the body may be dull bronzy, blue black, or metallic blue, with tinges of dark green to violet. Scape below is usually brown, the pedicel above metallic. Except the terminal segment, the tarsi are white ; the mid-tibiae are also white at extreme tip.

Biology and description of immature stages

Oviposition.—All the pre-imaginal stages of the fly are passed apparently well-protected within the pods, yet its larval stage is accessible to the parasite. It seems that the weak point in the life-history of the fly is the fact that the full grown larva cuts out a hole in the pericarp, leaving the epidermis intact and lies close by for pupation. This hole, though actually made to facilitate the emergence of the adult fly, exposes its larva to the attacks of the parasite. Several attempts were made, but the actual process of oviposition was not observed. It, however, seems probable that the female parasite thrusts its ovipositor through this hole, stings the host larva within and deposits its eggs on or close to the larva. This assumption is supported by the observation that in almost all cases of parasitisation the host larva was found in a full-grown stage when it had already cut the hole in the pericarp and the eggs were always found close to this hole. Usually one to four eggs are laid on a single host, the maximum number recorded being nine in one case.

The egg (Plate III, fig. 1).—It is spindle-shaped, broadly rounded at one end and gradually tapering to a fine point towards the other. The narrow half is usually slightly curved, giving it definite convex and concave surfaces. It is translucent white, with a bluish tinge and measures about 0.60 mm. in length and 0.15 mm. in breadth at the thick end.

The incubation proceeds extremely fast. At room temperature during April and May and at constant temperatures of 22°C and 27°C, the eggs hatched within a day. At 17°C, they took 2-3 days to hatch (Table II).

The grub.—Like other ectoparasites, the grub of this Eulophid attacks the paralysed host larva, punctures it and feeds on its body contents. Not only does the host larva provide sufficient food for the complete grub stage of the parasite, but it may even suffice in some cases for two or three parasite grubs. The shape and form of the grub presents no peculiar features. The head consists of a colourless glistening capsule, the three thoracic segments are large and mark the maximum thickness of the grub. The three thoracic segments and the first six abdominal segments bear dorsally a row of setae, one on each segment, close to their anterior margin.

TABLE II. *The pre-imaginal stages (in days) of the parasite at different constant temperatures*

Temperature °C	Incubation period		Larval period		Pupal period		Total pre-imaginal period
	No. of observations	Average period	No. of observations	Average period	No. of observations	Average period	
17	6	2.7	6	20.5	6	19	42.2
22	7	1	5	8.0	8	7.6	16.6
27	10	Less than one day	5	5.0	8	5.0	10.5

The abdominal segments appear dark-brown owing to the food contents inside. The rest of the body is white with a bluish tinge. The last four abdominal segments successively decrease in size thus producing a narrow, tapering posterior end. The size of the full-grown grub is variable just like that of the adult. An average full-grown female grub (Plate III, Fig. 2) is 3.0 mm. long and 0.8 mm. broad.

The grub stage lasts 5-6 days at 27°C, 7-9 days at 22°C and 20-21 days at 17°C (Table II).

The pupa.—The full-grown grub pupates within the pod and it may be mentioned that but for the hole made by the host larva for the emergence of its own fly, the parasite would have been doomed to life-long imprisonment, because by this time the pericarp of the pod gets so hard and dry that it would be impossible for the parasite to cut through. This seems to be an interesting adaptation of the parasite to attack the host only at such a stage when the latter has prepared the way for the successful emergence of its own adult.

The pupa (Plate III, fig. 3) possesses large oval eyes, with the antennæ folded round it and reaching a little beyond the base of wing-pads. The thorax bulges out dorsally and is about as long as the abdomen in the male. The abdomen of the female is however longer than the thorax. The abdomen is elongated and tapering posteriorly in the female, it is short and bluntly rounded at the posterior extremity in the male.

Besides the difference in form, the male and female pupæ can be easily distinguished by the difference in size, the female pupæ being always larger. Even in the same sex, the pupæ present considerable variation in size. The length of the female pupa usually varies from 2.5 to 3.0 mm., the breadth from 0.7 to 0.8 mm. The male pupæ, like the

adults, fall into two categories. The majority of them measure 2.0 to 2.2 mm. in length and 0.65 to 0.73 in breadth, while some specimens are found to be 1.5 mm. long and 0.5 mm. broad. These give rise to adults of two different sizes, as stated previously. The pupal period lasted 4-5 days at 27°C, 7-8 days at 22°C and 18-19 days at 17°C.

Seasonal history and incidence.—From the data about the rate of development of the parasite presented above (Table II), it will be clear that one generation is completed in 10-12 days at 27°C, 16-18 days at 22°C and 40-43 days at 17°C. This shows that the threshold of development of the parasite is fairly high and therefore the development is extremely slackened even at 20°- 22°C. This may be the reason why the parasite is very rare in winter. With the advent of spring, it rapidly increases in number, and in March four to seven per cent of the host larvæ are found parasitised. The extent of parasitisation goes on rising steadily up to April, when it is as high as 50%. The fact that under suitable conditions of temperature, the parasite develops one and a half times as fast as the host indicates the potentialities of the parasite in controlling the host, provided it can be suitably carried through severe winter by artificial means.

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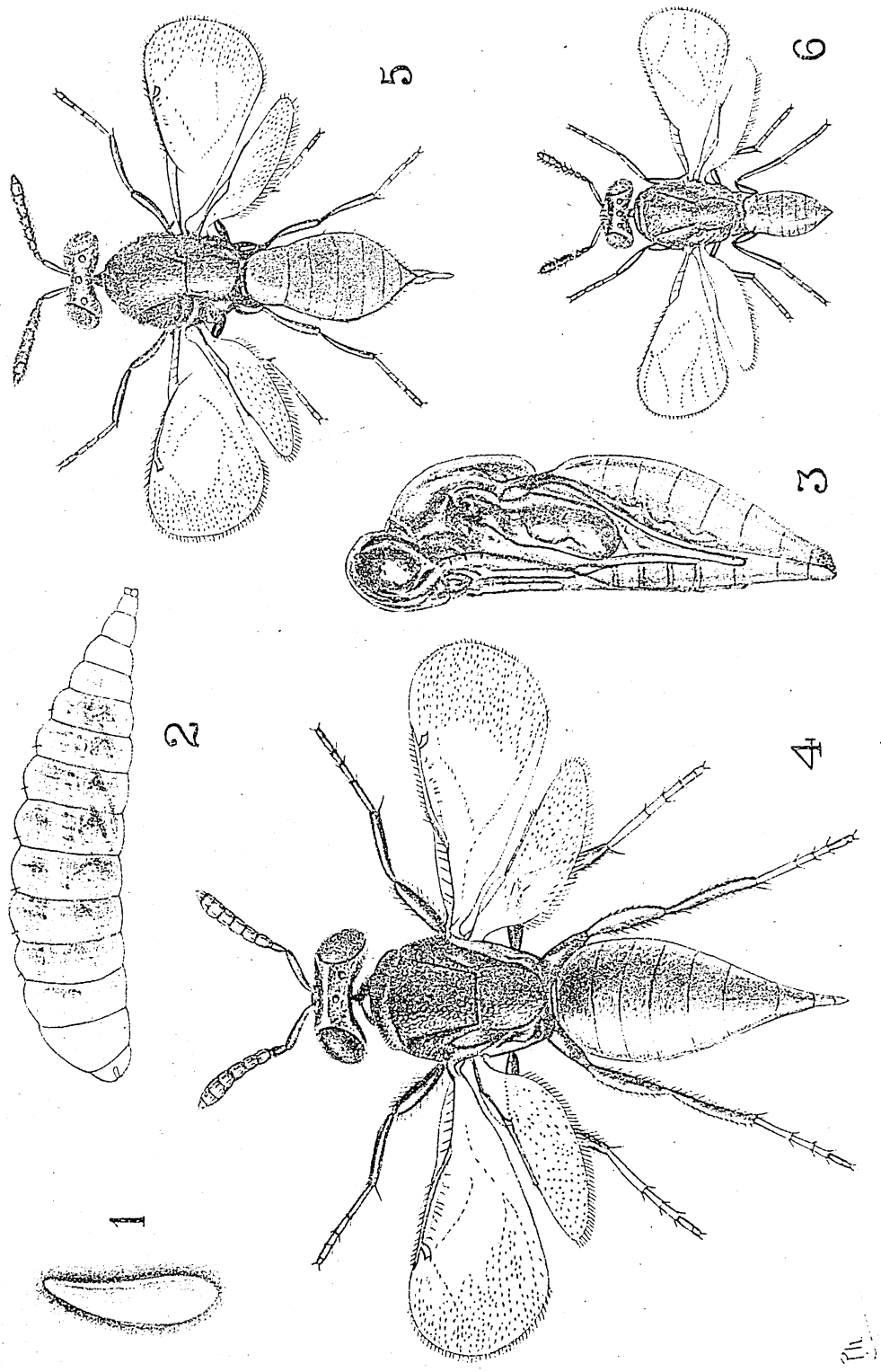
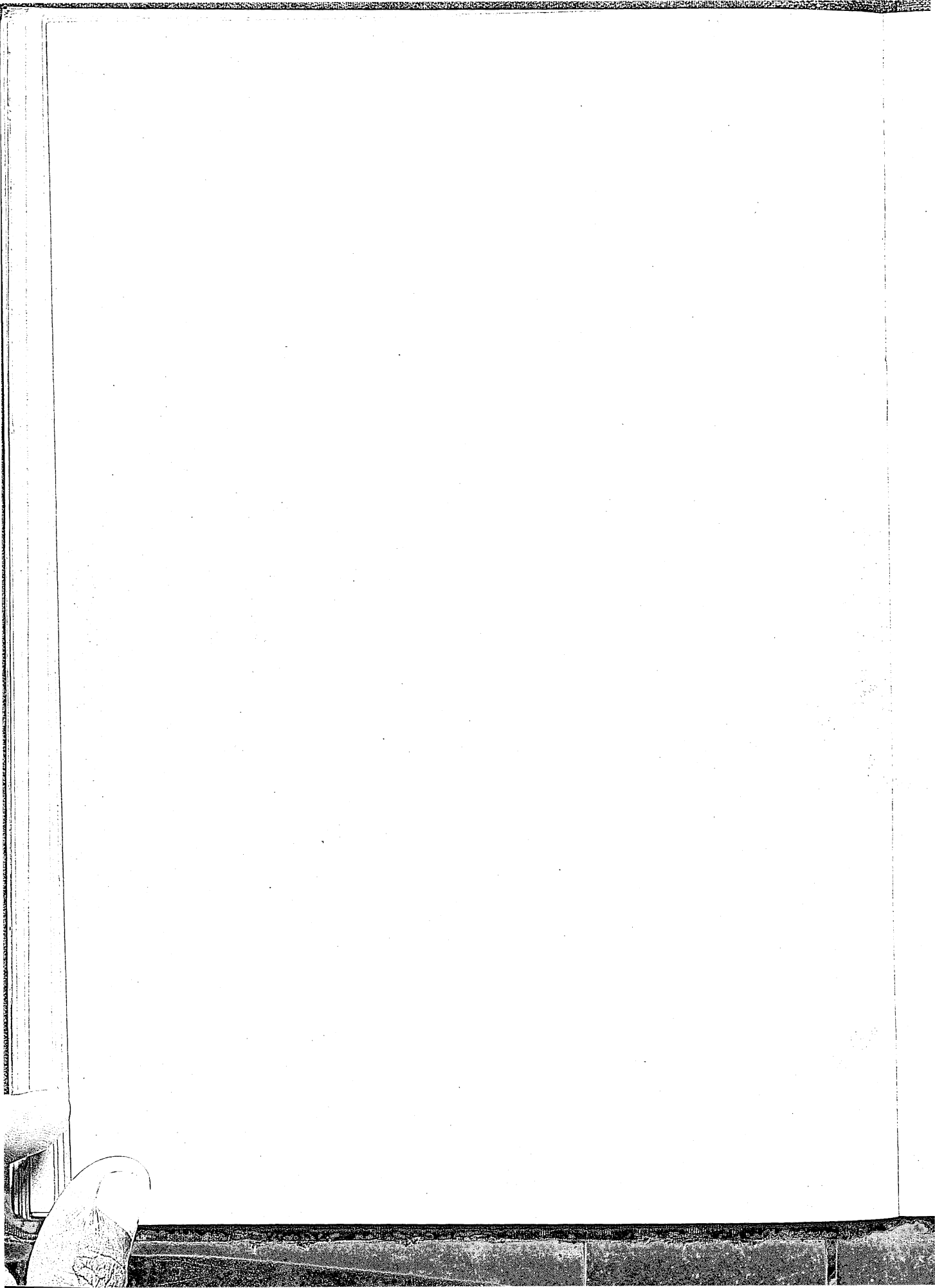
Explanation of Plate III.

Euderus lividus (Ashmead), a larval parasite of *Agromyza obtusa* Mall.

Fig. 1. Egg; (× 44).
Fig. 2. Grub, full-grown; (× 24).
Fig. 3. Pupa, female; (× 24).
Fig. 4. Adult parasite, female; (× 24).
Figs. 5-6. Adult parasite, male; (× 24).



EUDERUS LIVIDUS (ASHMEAD)



ON THE BIOLOGY OF *SPILONOTA OCELLANA* SCHIFF. IN BALUCHISTAN

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INTRODUCTION

Spilonota ocellana Schiff. (Eucosmidæ, Lepid.), generally known as the apple bud-moth in the United States, is fairly common in Baluchistan. A brief account of the pest was given by Pruthi (1935 & 1938). But in view of its importance, the writers have made a detailed study of the biology of the insect during the last three years, and the results are recorded in this paper.

The writers feel indebted to Dr. Hem Singh Pruthi, Imperial Entomologist, for the elucidation of certain points regarding this insect; to the Imperial Institute of Entomology, London, for the identification of the species and to M. Sabir Janjua, our Entomological Fieldman, for his help in the field and the laboratory.

DISTRIBUTION

The genus *Spilonota* Stephens, which includes about fifty species, is characteristic of the Indo-Malayan region, Australia and New Zealand. *Spilonota ocellana* Schiff. is, however, common in nearly all parts of Europe, except the most southern countries. It is widely distributed in North America where it is found on apple, pear, quince, plum, peach, cherry, blackberry, raspberry, hawthorn, oak, mountain ash, etc. It is also found in Eastern Siberia and Japan. In India several other species of *Spilonota* (*S. rhothia*, *S. calceata*, etc.) have been found as pests of various plants (Fletcher, 1932), but *Spilonota ocellana* has so far only been recorded from Baluchistan (Pruthi, 1935), where it is found in whole of the Quetta-Pishin district. Zhob and Loralai districts are, however, free from this pest. It also occurs at Mastung and Kalat.

FEEDING HABITS

In Baluchistan, the larvæ of the bud-moth have been observed damaging apple, plum, peach, quince and cherry. It has been noticed

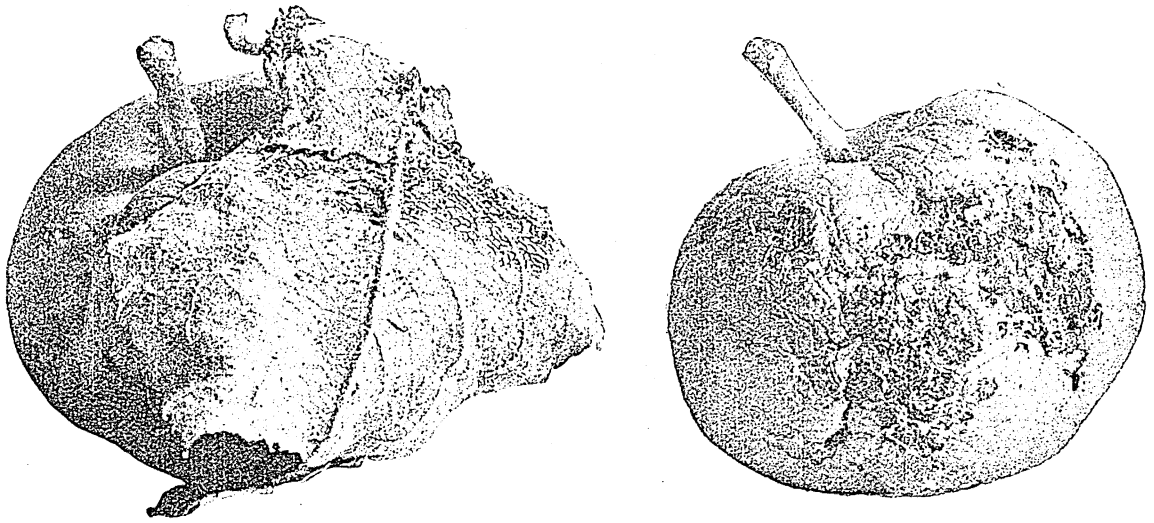
to be a serious pest of apple and quince while the incidence on other food plants is very low, the attack being confined only to leaves and immature fruits.

The injury caused by the larvæ to apples may be described under the following two heads : (1) Damage caused by the partly-grown overwintering larvæ to flower buds, foliage and young fruit ; and (2) damage to mature fruit.

The partly-grown overwintering larvæ emerge from their winter hibernacula in spring and first attack the young flower buds. If the bud has not yet opened, the larva bores into it from the tip, chewing its way and feeding therein. If it has already opened or is unfolding, the larva starts feeding into the cluster. As a result thereof, most of the clusters are spoiled and the setting of fruit is greatly reduced. When the trees are in full bloom, it has invariably been noticed that the larvæ instead of completely damaging a cluster, eat and web a portion of it and then move to the adjoining ones to repeat the same process with the result that the attacked clusters are weakened to a very great extent and little fruit is set. Soon after the setting of the fruit during 1937, an examination of the blossom clusters of *kulu* apple was made to determine the exact amount of damage caused by the pest. Five hundred blossom clusters, which were completely free from attack, were found to have set 609 apples, while the same number of clusters of the same variety in an infested orchard was found to have set only 193 apples, thus showing a reduction of 68.3 per cent. Similarly in 1938, observations on the same variety made in another orchard showed a reduction of 67.4 per cent.

When the blossom is over, the larvæ tie two or three leaves together with silken threads exuded by them and feed within the shelter thus made. After feeding for sometime on the green tissue they settle down and construct a tubular nest, usually in a fold or the curled portion of a leaf and invariably at places where it touches another leaf. The petiole of the leaves, except the one on which the nest is made, are severed at the base and the leaves are fastened together to form a loose and bulky nest. The larva occasionally comes out of its nest and feeds on the epidermis and the parenchyma tissue of the leaves giving rise to small skeletonized areas which increase in size as the larva grows. As a result thereof, the whole cluster is skeletonized and ultimately dries up and dies. Such dried up clusters are quite conspicuous during June, July and August and can be seen even from a distance. In severe infestations, about twenty to thirty per cent of the leaves are damaged in this way. But it is very difficult to assess exactly the damage caused to the leaves by this pest as similar damage is also done by the larvæ of *Cacoecia* spp. Newly formed apples are frequently enclosed in these clusters and are nibbled

by the larvæ causing them to drop or to become disfigured when they mature. The fruit stalks are sometimes gnawed by the larvæ which weaken them and cause the small fruit to drop. Often the larvæ also bore into the terminal shoots causing the tip to die.



A B

FIG. 1. Apple fruits showing nature of damage.

Late in summer, the larvæ attack such fruit which are touching some leaves. The leaf is first tied together by means of silken threads to the surface of the fruit (Fig. 1, A), then the larva builds a silken tube between the two and feeds on the leaf as well as the surface of the fruit. The fruit is not bored but is damaged superficially (Fig. 1, B). This greatly reduces the value of the fruit. It has been estimated that about 15-20% of the fruit crop is spoiled in this way.

DESCRIPTION OF VARIOUS STAGES IN THE LIFE-HISTORY

The egg (Fig. 2, A):—The eggs are laid singly but occasionally several may be seen overlapping one another. They are deposited on both sides of foliage and are fastened to the leaf by a sticky substance.

The egg is oval, flat, disc-shaped and almost transparent when fresh. Later it becomes waxy-white in colour, resembling a small flat drop of translucent wax. The average length is 0.88 mm. and width 0.74 mm. The surface is finely pitted and divided into irregular closed cells by many fine and inconspicuous ridges which are more clearly visible along the edges. In four or five days old eggs the progress of the development of the embryo can be seen through the thin egg-shell. A few days before

hatching, the brown mandibles and other mouth-parts appear; shortly afterwards, the black head and thoracic shield are seen. The larva finally emerges by cutting a hole in the chorion with its mandibles.

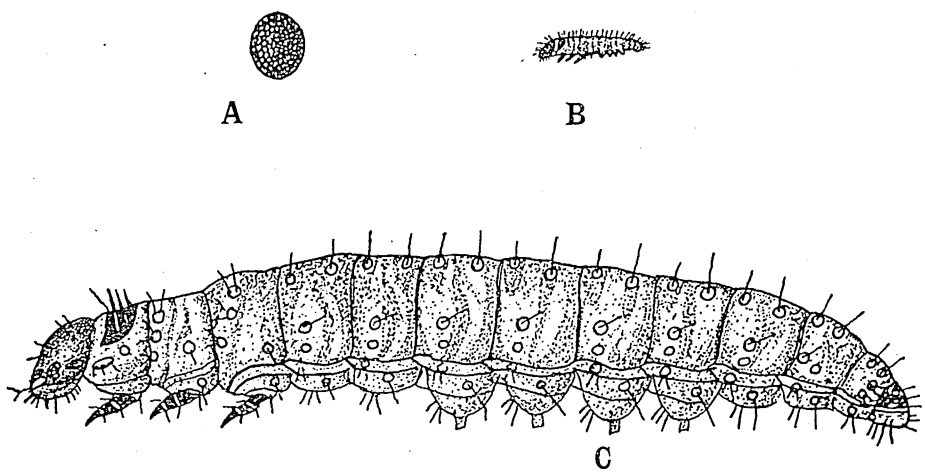


FIG. 2. Egg (A), young larva (B) and full-grown larva (C) of *Spilonota ocellana*.

The larva (Fig. 2, B & C).—The freshly hatched larva wanders about on the leaf, gnawing small pits in the tissue and spinning silk to enable it to maintain its position on the foliage. Ultimately it settles down and constructs tube-like nest between two leaves tied together to form shelter as already described. These tubes are formed on the under side of the leaves usually along the midribs or larger veins. They are white or slightly creamy in colour and usually open at both ends; as the larva feeds, "frass" is ejected from one end of the tube with the result that it soon becomes gray or black due to the accumulation of fecula. The tubes increase in size as the larvæ grow and inside these they moult at intervals. The larvæ seldom go out of these tubes but sometimes abandon them and construct new ones.

The number of instars and the moulting habits of the larvæ have been studied in detail in most of the countries where *Spilonota ocellana* is found. In Canada there are seven moults (Sanders and Dustan, 1919); at certain places in the United States of America there are six (Porter, 1924), while at others there are even eleven or twelve moults (Frost, 1927). We have observed six larval instars in the Quetta valley and the description of the various stages is as follows :—

First stage.—Length when newly hatched 1.03 to 1.2 mm., head 0.22 mm. wide. Dirty white in colour turning soon to yellow and

ultimately to light brown ; head shining black ; mouth parts much lighter in colour ; thoracic shield dark gray ; anal plate at first concolourous with the body but later becoming gray ; thoracic legs dusky ; body with a few long white hairs.

Second stage.—Length soon after moulting 2.4 mm., head 0.3 mm. wide. General body colour light brown ; head and thoracic shield very dark brown to shining black ; anal plate shield-shaped, dark brown ; thoracic legs very dark brown ; tubercles distinct, light brown in colour, each bearing a single creamy-white hair.

Third stage.—Length soon after moulting 3.1 mm., head 0.4 mm. wide. General body colour dull brown ; head and thoracic shield shining black ; thoracic legs black ; tubercles distinct, shiny ; hairs moderately long, sparse, white ; spiracles small, round, ringed with black.

Fourth stage.—The larva goes into hibernation in this instar and moults during the construction of the hibernaculum. Length in hibernating condition 3.4 mm., length when fully fed after emergence in spring 5 mm.; head 0.4—0.5 mm. wide. General body colour reddish-brown ; head and thoracic shield shining black ; anal plate markedly shield-shaped and of rich chocolate-brown colour with the exception of the posterior tip and a narrow anterior band which are much lighter ; thoracic legs dark brown to black, bearing many bristle-like hairs ; tubercles conspicuous, shiny and concolourous with the body ; hairs short, white, sparse ; edges of spiracles raised, pimple-like, darker than general body colour. Head, prothoracic shield and anal plate bearing silky hairs.

Fifth stage.—Length after moulting 7.4 to 8.3 mm., head 0.73 mm. wide. General body colour dull reddish-brown ; head and thoracic shield dark brown to black, shining ; mouth parts brown ; tubercles inconspicuous, flat, spreading coarsely, pitted, each bearing a fairly long yellowish seta.

Sixth stage (Full-grown larva).—Length 12 to 16 mm. ; head 1.05 mm. wide. General body colour dark brown, in some specimens dull brown ; head brown or almost black, shining ; thoracic shield concolourous with head, divided into two halves by a narrow brown medio-dorsal line ; mouth parts brown, lighter than head ; antennæ pale at base, darker at tips ; anal plate very dark brown ; thoracic legs black, crochets biordinal and in a complete circle ; tubercles oval to egg-shaped, spreading, slightly darker in colour than body, coarsely pitted ; spiracles conspicuous, round, ringed with black.

When the larva is about to pupate, it leaves its feeding shelter and finds another sheltered spot usually in the cluster of leaves and spins its cocoon. Inside the cocoon the larva loses much of its brown colour and becomes dirty grayish-white until it transforms into a pupa. Before pupating, the larva excavates a short passage in the cocoon for the pupa to wriggle out.

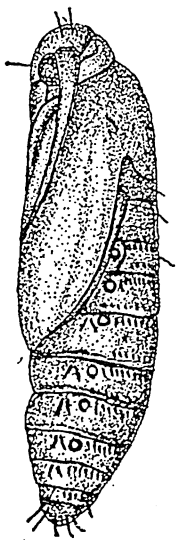


FIG. 3.

The Pupa (Fig. 3) :—The pupa measures 7 to 8 mm. in length and about 2 to 2.5 mm. across the third abdominal segment. General body colour is brown, the abdomen being a shade lighter than the rest of the body. It is slender, the abdomen tapering gradually towards the posterior end and terminating in a rounded segment. The spiracles are prominent, round, raised, pimple-like, darker in colour than abdomen. On each of the abdominal segments there are two transverse rows of spines, a row of strong spines on the anterior margin and a row of weaker spines across the middle of each segment. The last segment bears on the dorsal side ten strong spines at the tip. The cremaster is absent and the anal segment has eight bristles which are incurved at tip and are arranged in a circle, four singly on the segment, the remainder being present in two pairs. The maxillary palpi are about twice as long as the labial palpi and completely enclose the latter. Antennæ comparatively long, reaching nearly the edge of the wing pad.

When the moth is about to emerge, the pupa thrusts out about three-fourths of its body from the cocoon and the crumpled leaves. The case splits open and the adult moth emerges.

The Adult.—The moths fly at dusk only ; during the day they are seen on stems, twigs and under surfaces of leaves. If disturbed, they fly for a short distance. They are seldom attracted to light or sugar baits. Meyrick (1927) described the adult moth as follows :—

> " 13-17 mm. Forewings whitish, sometimes partly suffused grey, more or less strigulated dark fuscous ; basal patch dark grey, sometimes blackish mixed, edge somewhat angulated ; central fascia forming a dark grey sometimes indistinct costal suffusion, and black-edged triangular praetornal spot ; ocellus edged leaden-metallic, enclosing several sometimes confluent black dashes ; cilia dark grey. Hindwings rather dark grey."

DURATION OF VARIOUS STAGES AND SEASONAL HISTORY

The seasonal history of this species has been studied in several countries and is practically the same at all places, the duration of the

various stages being of course different in different localities. In Canada (Sanders and Dustan, 1919), United States (Porter, 1924, Frost, 1927 and Gilliat, 1932) and France (Paillot, 1935) there is one generation in the year, commencing with the egg stage in midsummer and ending with the deposition of eggs for the succeeding generation during midsummer of the following year. A brief account of the seasonal history of the insect in Baluchistan has previously been given by Pruthi (1938). As a result of investigations carried out by us during the last three years it has been ascertained that as in other countries there is one generation of the bud moth in the Quetta valley in a year.

During 1936 the first eggs were deposited on May 19, but ovipositions were continued up to June 27. In 1937 and 1938 eggs were laid on May 14 and May 22 and oviposition continued up to June 21 and June 30 respectively. The incubation period of the eggs varied from 7 to 13 days, with an average of 9.9 days. In 1936 it varied from 7 to 11 days, in 1937 from 8 to 12 days, while in 1938 it was from 8 to 13 days.

During 1936 eggs commenced hatching on May 30 and continued uptil July 5. In 1937 hatching started on June 1 and continued uptil July 10, while in 1938 hatching was in progress from June 3 to July 13.

The feeding period of larvæ ranges from 120 to 130 days with an average of 124.8 days; in 1936 it was 120 to 125 days, in 1937 from 124 to 130 days while in 1938 it was from 123 to 128 days.

A few weeks before the setting in of autumn, the larvæ begin to desert the leaves and go into hibernation. The earliest date on which the larvæ were found in hibernation in 1936 was September 30; in 1937 it was October 4 while in 1938 it was October 2.

The partially grown larvæ pass the winter in tiny silken nests or hibernacula which are invariably seen under bud scales, in the angle at the base of a fruit spur or a short twig, in a crevice in a bark or in any other convenient shelter near the dormant buds. These nests are usually 3-5 mm. long and vary greatly in shape, some being straight, others curved to conform to the space in which they are constructed. The hibernacula are never found in masses, each being separate from the other. The inner lining of the nest is white and quite tough in texture, while to the outside, bits of frass, tiny pieces of bark or bud scales are attached which make it almost resemble the bark and thus indistinguishable from the surroundings.

Securely enclosed within the hibernacula, the larvæ pass the winter and with the approach of spring when the flower buds begin to open and the development of the tender young foliage starts, they become active and come out of their winter hibernacula. In 1937, the first larva emerged on April 5 and the last on April 26, while in 1938 the first larva emerged

on April 9 and the last on April 27. The length of time spent by the larvæ in hibernation ranged from 176 to 190 days, with an average of 181.4 days; in 1936-37 it was from 176 to 190 days, in 1937-38 it was 177 to 188 days, while in 1938-39 it was 180 to 189 days.

On emerging from the winter quarters the larvæ attack flower buds, young leaves, etc., as described in the beginning of this paper. The feeding period of these overwintering larvæ ranged from 28 to 37 days, with an average of 32.7 days; in 1937 it was 29 to 32 days, in 1938 from 28 to 33 days and in 1939 from 30 to 37 days.

At the end of the feeding period the larvæ seek sheltered places in the tied-up clusters, etc., and start spinning cocoons. Three or four days after the cocoons are spun, they turn into pupæ. The pupal period varied from 9 to 19 days, with an average of 11.9 days. In 1937, it varied from 9 to 12 days, in 1938 from 9 to 15 days, while in 1939 it was from 9 to 19 days.

The moths usually start emerging by about the middle of May and continue up to the end of June and sometimes they may even be seen in the beginning of July. The length of life of the adult varied from 8 to 20 days, the average being 14.8 days during May-June, 1938.

Copulation takes place soon after the adults emerge and the preoviposition period varied from 2 to 5 days, with an average of 3.5 days. Table I summarizes the observations on preoviposition period taken during 1938 and 1939.

The egg laying activities of the moth were observed in detail. Oviposition occurs at night and as the time for oviposition approaches, there are indications of excitement on the part of the female. After sometime she becomes quiet when the tip of her abdomen touches the surface on which she rests. She slowly lifts the tip of her abdomen and lays an egg. This process is repeated again and again until several eggs are laid in succession. In the case of one female observed, twenty eggs were laid in 30 minutes. The average number of eggs deposited per female moth was 52.7, 10 females depositing 527 eggs. The maximum number of eggs deposited per female was 123 and minimum 19.

The life-history may be summarized as follows :—

TABLE I. *Summary of the life-history data of* Spilonota ocellana

Stage in life history	Maximum (days)	Minimum (days)	Average (days)
Incubation period of eggs	13	7	9.9
Feeding period of larvæ before going into hibernation.	130	120	124.8
Hibernation period of the larvæ	190	176	181.4
Feeding period of overwintering larvæ	37	28	32.7
Pupal period	19	9	11.9
Life of adult moths	20	8	14.8
Preoviposition period	5	2	3.5
Number of eggs deposited per female	123	19	52.7

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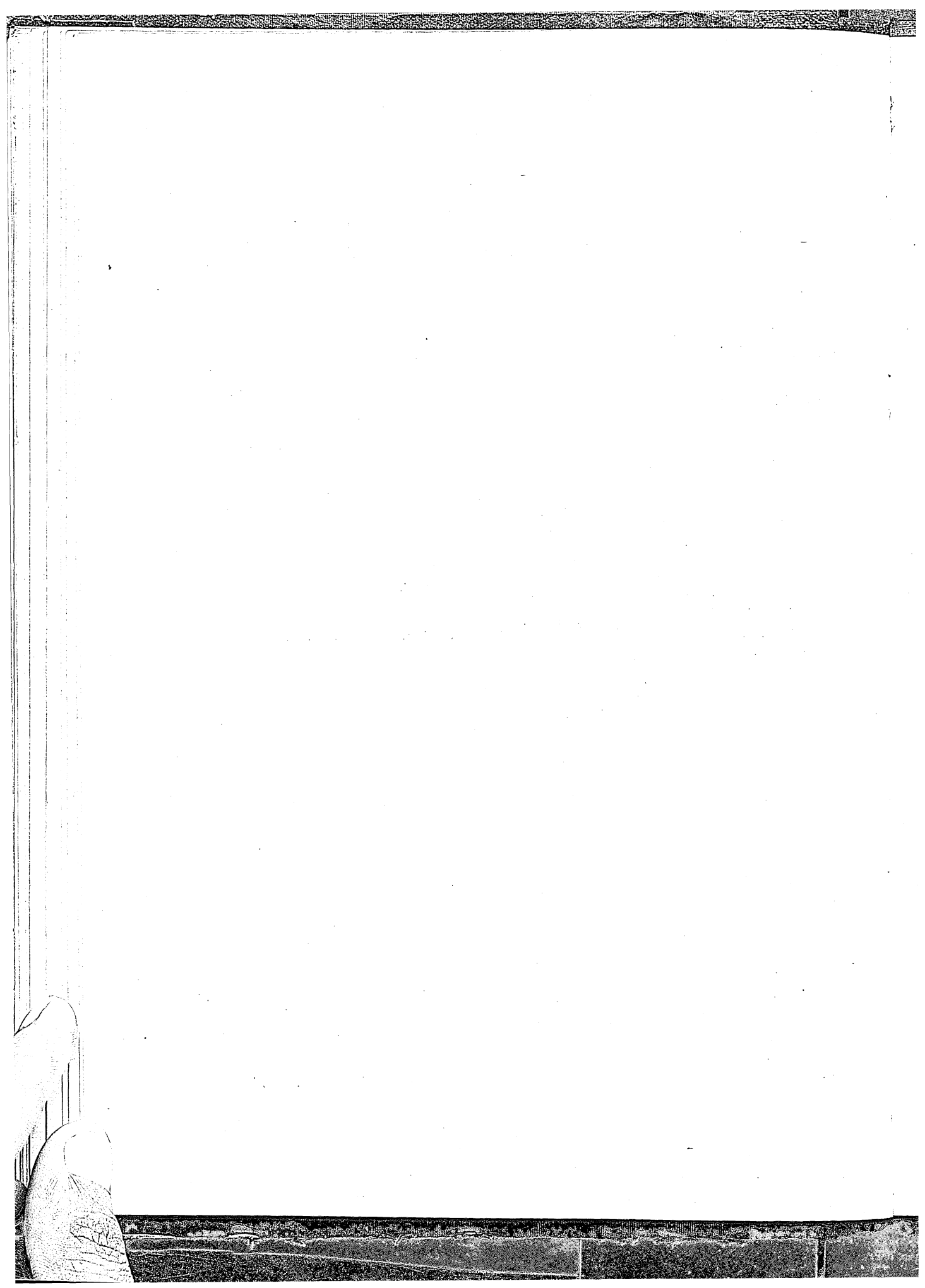

TETRASTICHUS AYYARI ROHW.—A PUPAL PARASITE OF SOME MOTH-BORERS IN SOUTH INDIA

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INTRODUCTION

The Chalcidoid, *Tetrastichus ayyari* was described by Rohwer (1921) from eleven female specimens found parasitic on the pupæ of *Chilo zonellus* (Swinh.) and forwarded to him from Coimbatore by Dr. T. V. Ramakrishna Ayyar. Rohwer did not describe the male but we have seen several specimens of this sex. The males are smaller than the females and can be distinguished from the latter by the colour and structure of the antennæ. The antennæ of the male are more slender, yellowish and tipped with black, while those of the female are black and with longer bristles.

SPECIES OF *Tetrastichus* RECORDED FROM INDIA

About fifteen years ago, Ayyar (1925) published a list of the Indian species of *Tetrastichus* Haliday. Mani (1938) listed sixteen species of this genus from the Indian region and of these, eight are from South India. Recently Cherian (1939) has recorded two more species from South India, *viz.*, *T. sokolowskii* Kurdj., and *T. echthrus* Crawford.

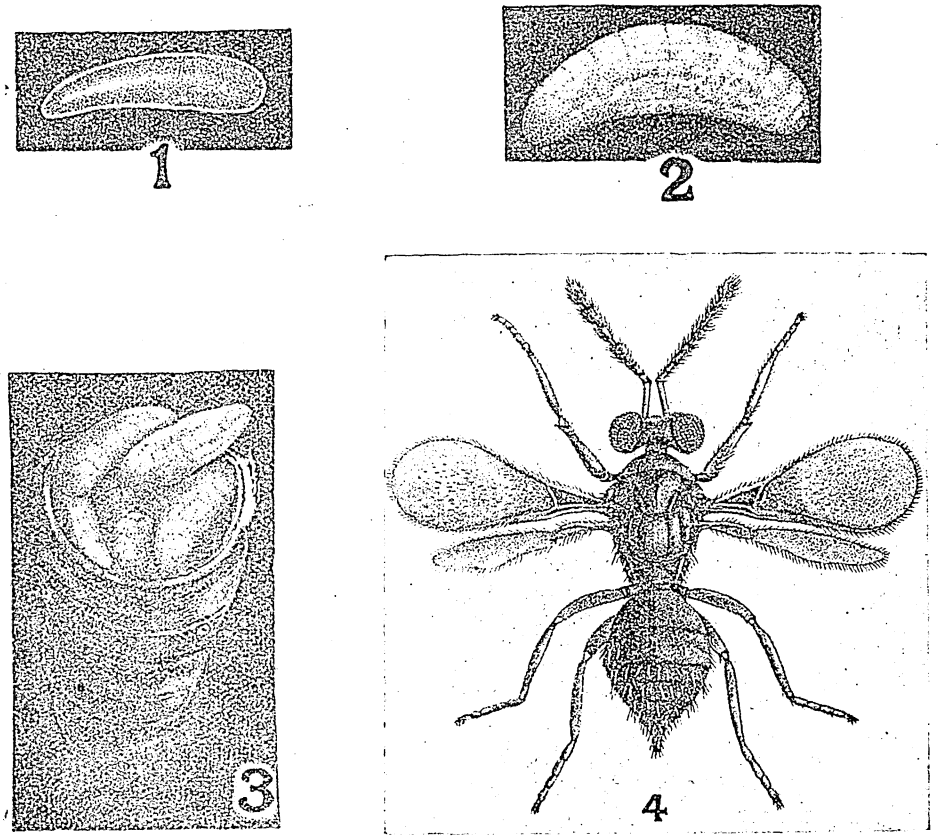
HABITS AND LIFE-HISTORY

The adult parasites escape by biting holes in the host pupæ, sometimes three to six holes being found on each pupa. Emergence of the parasites generally takes place in the mornings. Soon after emergence, they become active, take food and copulate. Eggs are laid, in some cases, even on the day of emergence. The parasites accept fresh as well as slightly old pupæ for oviposition.

Eggs are laid in the body fluid of the host. When freshly laid, they are smooth, shining and transparent. The egg (Fig. 1) is longer than broad, curved and tapering towards the posterior end and measures 0.28 to 0.32 mm. long and 0.06 to 0.10 mm. broad. The incubation-period is about one day. The maximum number of eggs laid by a female of one lot, as determined by the number of adults emerged, was 98. Eight females of another lot laid 81, 77, 76, 75, 72, 72, 71 and 58 eggs respectively, the average being 72.8.

The newly-hatched grub is flat and transparent and its segments are fairly well defined. It is 0.4 to 0.5 mm. long and 0.1 to 0.16 mm.

broad. The grubs feed on the body fluid. The mature grub (Fig. 2) measures 1.46 to 2.75 mm. long and 0.4 to 0.84 mm. broad. It is smooth, shining, slightly curved and tapering gently towards the anterior



FIGS. 1—4. Different stages of *Tetrastichus ayyari* 1. The egg. 2. The full-grown gurb. 3. Pupæ. 4. Adult female.

and posterior ends. When mature, the grub begins to excrete shining, yellowish pellets, which are either found dumped near the wall of the host pupa or between the grubs. The larval period is seven to eight days. The prepupal stage lasts for a day or two.

The pupa (Fig. 3) when fresh, is white and glistening, but in about two days it becomes black and the eyes turn red. The female pupa is 1.52 to 2.04 mm. long and 0.48 to 0.66 mm. broad and the male 1.24 to 1.6 mm. long and 0.38 to 0.46 mm. broad. The pupal period is six to seven days. The total life-cycle from egg to the emergence of the adult is fourteen to sixteen days. The female is illustrated in Fig. 4.

When fed on dilute honey, in the laboratory, the maximum longevity of a female was 37 days and of a male 38 days. The average longevity of 10 females, was 23 days and of 10 males 25 days. Without food the parasites do not live for more than three days.

The progeny of eight pairs kept under observation in November-December, 1939 was 35 males and 547 females, the proportion of the sexes being 1 male : 15.2 females. Parthenogenesis is also observed in the species. In one host pupa collected from the field in July, 1938, all the parasites were found to be males.

Hosts

T. ayyari has been reared by the authors from the pupæ of *Chilo zonellus* (Swinh.), *Argyria sticticraspis* (Hampson) and *Diatraea venoseta* (Walk.). Brahmachari noted this parasite once on *Sesamia inferens* (Walk.). Under laboratory conditions, the parasite was found to breed in the pupæ of *Attacus ricini* (Boisd.), *Heliothis armigera* (Fb.), *Galleria mellonella* Linn., *Spodoptera mauritia* (Boisd.), *Crocidolomia binotalis* (Zeller), *Noorda moringae* Tams, *Plutella maculipennis* Curt., *Hyblaea puera* (Cram)., *Precis* (=*Junonia*) *orithya* (Linn.), *Prodenia litura* (Fb.), *Polytela gloriosae* (Fb.), *Dysodia viridatrix* (Walk.), *Platyedra gossypiella* (Saund.), *Sylepta derogata* (Fb.), and *Cirphis albistigma* (Moore).

Economic possibilities

From the point of view of its usefulness in controlling the pests named above, the parasite has certain advantages as well as drawbacks. It has a shorter life-cycle than that of its hosts. The egg-laying capacity and longevity of the female are fairly high, and the proportion of the females to males is very high. The authors have not come across any hyperparasites. Lastly, the parasite can easily be multiplied under laboratory conditions throughout the year. On the other hand the parasite only attacks the pupæ, while it is the larvæ, which do the actual damage to crops. The parasite attacks more than one host, and the eggs are not distributed but laid in clusters in the host.

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ON THE BIOLOGY OF *SPATHIUS VULNIFICUS* WILK. A POSSIBLE EFFECTIVE PARASITE OF *PEMPHERES AFFINIS* IN SOUTH INDIA

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INTRODUCTION

Towards the close of 1936, in the course of a general survey of the distribution and natural enemies of the cotton stem-weevil, *Pempheres affinis* Faust, a short tour was undertaken by the senior author in certain localities in North India. As a result of preliminary studies, this weevil was found to have only a few natural enemies in the field, which seemed neither numerous nor efficient in its control. A search, therefore, for suitable parasites in other regions as also for parasites of closely related species was deemed necessary. From literature and by correspondence with the Forest Research Institute, Dehra Dun, it was considered that Dehra Dun district would be a suitable centre for such an exploration and, therefore, a large collection was made from this region. The writer wishes to take this opportunity to express his gratitude to Dr. Beeson, Mr. Gardner and their staff for the help rendered in making the collections.

In the course of such collections the Braconid, *Spathius vulnificus* Wilkinson, was found commonly parasitising a species of *Dinoderus* (Bostrychidae), infesting stored bamboo at Jawalapur on the banks of the Ganges, about 30 miles south of Dehra Dun. A consignment of this material was imported and the present account deals with the studies made on the biology, behaviour, artificial rearing and possibilities of this parasite at Coimbatore.

Spathius vulnificus (Fig. 1) is a dark red, slender species which was originally described by Wilkinson (1931) from specimens collected at Coimbatore. Female : length 2.6 to 5.1 mm., averaging 4.05 for 12 specimens. Male : length 2.6 to 3.7 mm., averaging 2.96 mm. for 9 specimens. This species is very closely related to *S. critolaus* Nixon (1939), which also parasitises *Pempheres* and the sculpture of the first apparent tergite is the most reliable character for separating them.

NORMAL HOSTS AND DISTRIBUTION

Beeson and Chatterjee (1935) recorded this wasp as having been bred from *Dinoderus brevis* Horn, *D. minutus* Fabr., and *D. ocellaris* Steph., infesting *Dendrocalamus strictus*. The same authors have also

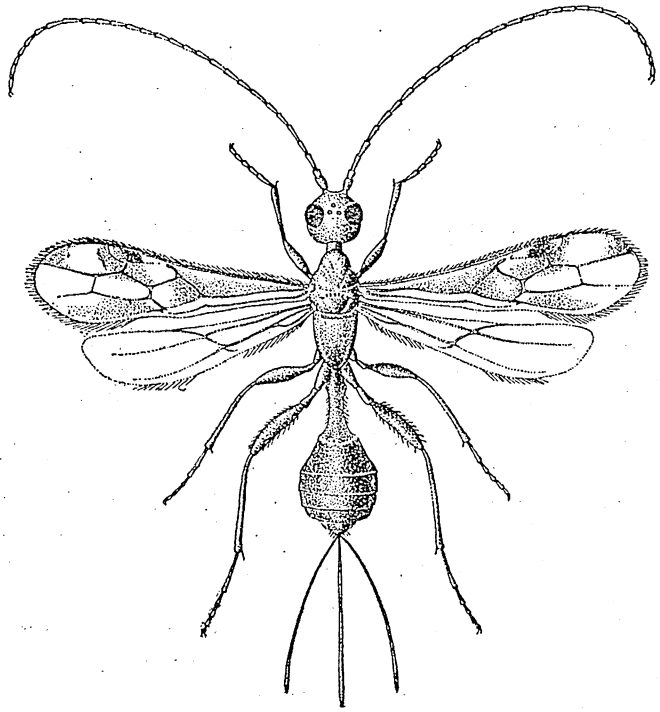

FIG. 1. *Spathius vulnificus* Wilkinson; female, × 14.

recovered it from mango planks attacked by *D. bifobiolatus* Woll., *Heterobostrychus aequalis* Wat., etc., and from planks of *Bombax malabaricum* infested by *Heterobostrychus* and *Lyctus* sp. It is evident from these records that its normal hosts are coleopterous wood-borers like Bostrychids, Lyctids and probably Cerambycids, which are at times closely associated with the former insects in similar situations. The parasite is widely distributed throughout India, having been recorded from Assam, Calcutta, Madras, Bombay and the Central and the United Provinces. From its geographical distribution, it appears that it is capable of tolerating considerable diversity in climate.

BIOLOGY AND LIFE-HISTORY

When the writer collected this parasite, practically nothing was known regarding its habits or life-history and it had never been observed to parasitise *Pempheres* or other weevils in nature. The interest and success of the introduction therefore depended on its adaptability to the new hosts. A few preliminary tests were carried out, the results of which were encouraging. The first essential requisite that the

parasite would mate and oviposit on *Pempheres* grubs in captivity was satisfied. It passed through its complete normal life-cycle on this host without difficulty. Another favourable feature noticed was its capacity to attack the grubs of **Hypolixus truncatulus* in cages. It appeared therefore, that a regular and systematic rearing of the species in the laboratory should be attempted. A total of 206 adults was actually reared on these hosts in the laboratory between December 1936 and April 1937. They consisted of 161 (149 ♀♀ and 12 ♂♂) on *Hypolixus* and 45 (37 ♀♀ and 8 ♂♂) on *Pempheres*. In the course of such rearings considerable data on the life-history and bionomics of the insect were obtained and these are summarized below :—

The adults are not very active in nature or in cages in the laboratory. They often take short flights and retreat to sheltered and shady portions in cages. Generally the females are more common than the males. Out of 383 adults that emerged from the imported material there were 302 females and 81 males. Among 206 adults reared in laboratory the females numbered 186 and the males 20.

Longevity of Adults.—The adults were comparatively short-lived if there was no supply of artificial food or water, the maximum life-span not exceeding 10 days. The life was considerably prolonged when a regular supply of sugar solution was made available in cages. The female lived up to 93 days, with an average of 40.6 days for 41 individuals, while the maximum for males did not exceed 72 days, with an average of 32 days for 3 individuals. Temperature and humidity curves of the period during which life-history was studied are given in Fig. 2.

Copulation.—As in most other Braconids, copulation often takes place soon after emergence. After pairing once or twice, some slight resistance may be offered by the female which the male is able to overcome. A male is capable of mating several times with the same female or with different females. The duration of copulation is generally very short, being on an average about half a minute.

Pre-oviposition period.—In this regard the mated females differed considerably from the virgins. A minimum period of four days after emergence seems to be necessary for the mated ones to commence oviposition, but the maximum interval may be 56 days. The average period was 13.5 days for 28 individuals. In the case of virgins, the minimum period was 9 days, with an average of 24 days for four females studied.

Oviposition.—It has been already mentioned that the parasite freely oviposits on *Pempheres* and *Hypolixus* and that the latter host, probably

* The name *Hypolixus* is used in preference to *Lixus* on the advice of Sir Guy A. K. Marshall, who considers the former to be of generic rank.

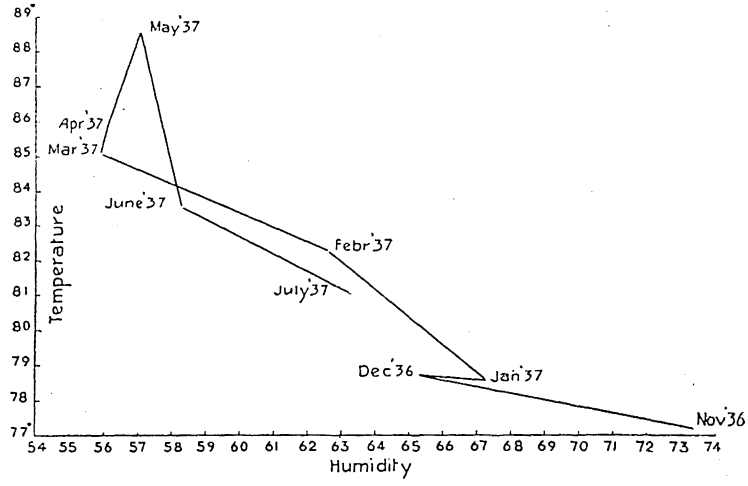

FIG. 2. Temperature and humidity curves for the period Nov. 1936 to July 1937.

due to its larger size, exerts a slightly stronger attraction. Preliminary trials revealed that stages other than grubs were generally left untouched. Among grubs, it is the full grown ones of *Pempheres* and the medium-sized ones of *Hypolixus* that are preferred. Oviposition experiments were conducted in large tubes ($6'' \times 1''$) containing small cotton stalks having 3 or 4 host grubs lodged inside scooped-out cells. The female after a preliminary exploration of the entire stalk selects a suitable site and extrudes fully its ovipositor, administering a series of thrusts into the stem and effecting a complete paralysis of the grub inside. The eggs are immediately laid on any part of the host's body, loosely attached in clusters or groups. The time taken for the completion of the entire process averaged 15 minutes. Not infrequently the paralysed host was not oviposited upon, and the female was not seen to feed at the puncture.

The maximum number of eggs laid by a single mated female was 89, the average for 28 females being 28 eggs. A certain percentage of females never laid any eggs at all and these have been eliminated from this computation. Unmated females also freely oviposit, but the highest number laid by a virgin never exceeded 21, with an average of 13 for 4 individuals. The number of eggs laid by a single mated female per day per host varied from 4 to 30. It may be also noted that more hosts are paralysed than actually oviposited upon. A single female on an average parasitised 6 hosts in its life time besides an average of 4 additional hosts merely paralysed. In Table I the data relating to 28 females studied are summarized.

The post-oviposition period is generally very prolonged, ranging from 1 to 43 days, with an average of 10.5 days.

TABLE I.

No. of eggs laid per ♀	No. of hosts parasitised per ♀	No. of merely paralysed stages per ♀	No. of total ovipositing days per ♀	No. of eggs laid per ovipositing day per ♀	No. of eggs laid per host per ♀	Max. No. of eggs laid per oviposition day per ♀	Av. Max. No. of eggs laid per host per ♀
28	6	4	4	6.5	4	13	12
(5 to 63)	(3 to 9)	(1 to 9)	(1 to 8)			(5 to 30)	(5 to 28)

Species belonging to the genus *Spathius* show considerable similarity in their general biology and immature stages. *Spathius critolaus* Nixon, a closely related species, has also the habit of parasitising Bostrychids in nature. *S. vulnificus* mainly differs from *S. critolaus* and *S. labdacus* Nixon in regard to oviposition. This species lays eggs in groups on the host, whereas others lay only one or two eggs per host. In *S. labdacus*, only one adult develops per host even though more eggs are laid on the same. In regard to fecundity, *S. vulnificus* is decidedly superior to others in that the maximum for *S. critolaus* is about 57 and that for *S. labdacus* is about 30 only. The sexes are not so disproportionate in other species and this suggests that parthenogenesis probably does not occur in *S. vulnificus*.

Description of immature stages

The egg.—It is translucent, white, smooth and shining and is subreniform in shape, with the caudal end narrow and somewhat curved and tapering. The cephalic end is broad and rounded. The length ranges from 0.76 mm. to 1.00 mm., averaging 0.88 mm., and the width from 0.13 mm. to 0.145 mm., averaging 0.133 mm., for 38 eggs. The egg takes from 40 to 64 hours for hatching, averaging 47 hours for 32 cases. Prior to hatching, the egg loses much of its translucency and assumes a pale yellow colour. The young larva gnaws out an irregular opening at the broad end. The egg shell at times remains attached to the larva till its first moult.

The larva.—A freshly hatched larva is slender, creamy-white, with a distinct head and well-delineated thirteen segments. The cuticle appears to be smooth and devoid of any conspicuous setae. The head is somewhat arched and chitinised and bears a pair of minute antennæ and sharp mandibles. Its average length is 0.88 mm. and width 0.21 mm. The average width of the head capsule is 0.093 mm. The young larva attaches itself to the host and starts imbibing the body fluids by suction. Within

an hour it assumes a yellowish-brown colour imparted by the ingested food. The larva, during subsequent development, changes very little except in size and shape of mandibles. Four distinct larval stages, inclusive of the final stage, can be recognised, mainly differentiated by increase in size and the development of urate granules. Each of these stages occupies about one day and the whole larval period occupies from 4 to 7 days, averaging 5 days. The average dimensions of various stages are given below :—

Stage	Number examined	Length	Width	Width of head shield
II	22	1.74 mm.	0.45 mm.	0.18 mm.
III	11	2.47 ,,	0.69 ,,	0.229 ,,
IV	24	4.36 ,,	1.06 ,,	0.229 ,,

The larva, when fully developed, is spindle-shaped, thickened in the middle and tapering slightly towards the extremeties. The ventral mouth-parts form the entire lower part of the head and are well chitinised. The general colour varies from pale yellow to yellowish-brown, with the gut opaque due to accumulated food. The tracheal system is well defined. The body is arched and the urate granules are distinctly larger and more pronounced. The growth of the larva during this stage is more rapid and the host gets fully consumed by this time with only the shrivelled cuticle and head capsule remaining.

The cocoon and pupa.—The process of cocooning begins with the cessation of feeding by the mature larva. A white, thin and papery cocoon is soon woven around itself in the tunnel and, being a gregarious species, several cocoons are found closely adhering to and overlapping one another. When cocooning is completed the larva throws out the meconium in small brownish-black lumps and turns into a creamy-white prepupa. The prepupal stage lasts 6 to 11 days, with an average of 7.6 days for 56 cases observed. The three new regions destined to be the future head, thorax and abdomen become defined at this stage.

The prepupa moults and turns into a pupa which is white in colour, with eyes, mouth appendages, antennæ, leg and wing rudiments clearly defined. After a day the white colour changes and successively becomes yellow, brownish, reddish-brown and deep brown in the course of chitinisation. When the adult parasite is fully formed, the pupal case gives way and the adult emerges out by cutting a circular opening at the head-end of the cocoon. The pupal period ranges from 6 to 13 days, the average being 9.8 days.

Duration of life-cycle

The duration of the entire life-cycle ranged from 19 to 29 days as may be seen from the table below :—

Month		No. of adults reared.	Minimum period (days)	Maximum period (days)	Average
December	1936	100	20	29	25
January	1937	15	24	25	24
February	,,	5	25	25	25
March	,,	10	19	26	21
April	,,	8	21	22	21

Parthenogenesis

Evidence on the occurence of this phenomenon in *Spathius vulnificus* is inconclusive. Virgin females appeared to oviposit normally though these were more reluctant in their layings and the egg-laying capacity was seen to be much reduced. But the progeny failed to develop to maturity in any of the observed cases. It is however probable that this species is parthenogenetic, since related species have been observed to be so.

Mortality

The number of adult parasites actually reared was found to be only 32.5 per cent of the total eggs laid. The number of adults obtained may be seen to be rather unnaturally low. This may be partly attributed to overcrowding of larvæ and the consequent insufficiency of food. Probably the larvæ are unadapted to the environmental conditions obtaining in cotton stems. The death rate is highest between the 2nd and 3rd stages of the larva.

Economic possibilities

Laboratory studies, made by the authors, indicate that the species is well adapted to parasitise the host, *Pempheres affinis*. It freely oviposits and develops on this host in cages and the ovipositor is sufficiently long to reach the borer stages inside the stems. Its reproductive capacity is comparatively great and its powers of dispersal, being a fully winged form, are obvious. It has also a comparatively short life-cycle. Development of a varying number of parasites from a single host facilitates easy multiplication though the method of oviposition may be regarded as wasteful. A Braconid with such desirable points in its favour apparently has con-

siderable possibilities in the field. On the other hand, the comparatively high rate of mortality and the low rate of multiplication in cages are factors that reduce, at least to some extent, its efficiency. There were unfortunately no opportunities for making any systematic liberations and it is therefore impossible to say whether the species can become established in the field. The studies, however, have been useful and instructive in that they have indicated the qualities to be looked for in an efficient parasite.

SUMMARY

In the course of an investigation into the possibilities of the biological control of the cotton stem-weevil, *Pempheres affinis*, many parasites of weevils, either closely allied or of similar habits were studied. Among these, the Braconid *Spathius vulnificus* Wilkn., found parasitising *Dinoderus* spp. infesting bamboo in storage in Jawalapur in U. P., proved to be of considerable interest. This parasite is closely related to *Spathius cretolaus*, which is a specific parasite of the stem-weevil. Considerable attention was, therefore, devoted to a study of the habits and biology of this imported parasite, with a view to its possible utilisation. In laboratory trials, the species readily oviposited on *Pempheres* grubs and successfully developed to maturity. Over two hundred parasites were thus reared in the laboratory and the life-cycle period ranged from 19 to 29 days during the period December 1936 to April 1937. An average of 28 eggs was laid per female, with the maximum rising up to 89. The highest number of eggs laid on a single host at a time was 30, but the average was as low as 4 per host per female. About 33 per cent of the eggs laid developed to maturity. The sexes were highly disproportionate, females greatly preponderating in numbers. Evidence regarding the occurrence of parthenogenesis in this parasite is inconclusive. The economic possibilities of the parasite are discussed.

In conclusion the writers wish to record their indebtedness to the Indian Central Cotton Committee for affording financial assistance for the investigation.

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ON THE WORKER BROOD-CELLS OF THE BEE, *APIS INDICA* F. IN THE PUNJAB

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INTRODUCTION

Bee-keeping in modern hives with *Apis indica* Fabr. was started by the Department of Agriculture, Punjab, at Nagrota (Kangra Valley) and Raison (Kulu Valley) in 1934 and 1935 respectively. The comb-foundation sheets (with twenty-four cells to four linear inches) were obtained from the Imperial Agricultural Research Institute, Pusa (now at New Delhi). The bees usually rejected this comb-foundation, but whenever it was accepted they did not use the walls of its embossed cells to build their combs.

The comb-foundation (with 19.3 cells to four linear inches) used for the Italian bees (*Apis mellifica* Linn.) in the United States of America and England, was also tried. The bees did not raise the combs from the walls of the embossed cells but did so at random. This resulted in irregular combs which had several cells too small for brood-rearing or any other purpose. During the honey-flow season (March-April, at Nagrota ; September-October, at Raison), however, the cells were drawn out from the raised cell-walls of the comb-foundation, and used either for storing honey and pollen, or for rearing drones, thus defeating the very purpose for which the comb-foundation is given. Occasionally the large cells, drawn out according to the pattern of the comb-foundation, were narrowed at the opening and used for rearing workers. The nature of cells in a comb built on Pusa or foreign comb-foundation is illustrated in Fig. 1.

Thus the two types of comb-foundations, Indian and foreign, available in the market proved unsuitable for bees in the Punjab. It was, therefore, decided to find out the proper size of the worker brood-cells in nature, with the object of evolving a mill suitable for the preparation of comb-foundation for *Apis indica* in this province. The work was carried out at Nagrota and Raison during 1936-38.

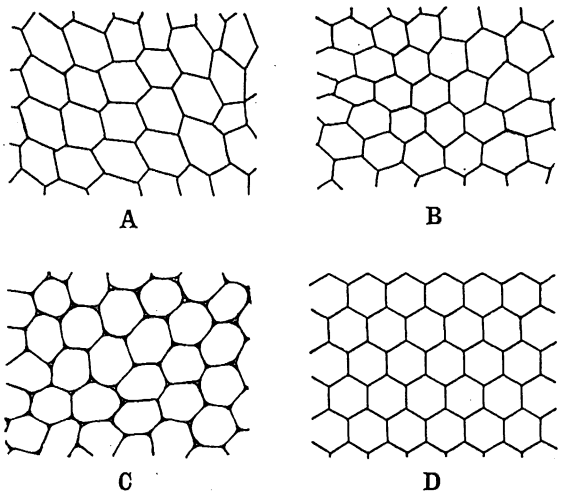

FIG. 1.—Nature of cells in a comb built on Pusa and foreign comb-foundations. A. oblique cells ; B. irregular cells ; C. cells with intercellular corners thickened; D. normal cells.

MATERIAL AND METHODS

Combs were collected from the apiaries of the local bee-keepers of Nagrota and Raison to measure the size of the cells. Seventy-three combs were measured at Nagrota and 162 at Raison, the total number of measurements made being 432 and 538 respectively.

Measurements were made according to the following three methods :—

(*i*) by placing a measuring rod on the comb and counting the number of cells per four linear inches*.

(*ii*) by enclosing a definite number of cells (usually twenty) between the two points of a divider, measuring the distance between them on a foot-rule and calculating the number of cells per four linear inches therefrom.

(*iii*) by placing a Zeiss microscopic glass measuring-slide with 100 mm. marked on it directly on the comb and measuring the distance between the outer walls of a definite number of cells (usually twenty). The slide was placed in position with division marks opposite the centre of the cell walls at its two extremes with a hand lens giving twelve times magnification. The number of cells per four linear inches was calculated according to the factor $1'' = 25.4$ mm.

* In order to minimise chances of error, the distance of four inches as a common unit of measurement was adopted at the suggestion made to the first author by Mr. H. H. Root of Messrs A. I. Root and Co., Medina, Ohio, U.S.A.

The first method was used only at Nagrota, but at Raison all the three methods were employed to begin with, but ultimately the third method was followed as it proved more accurate and easier to work with.

One horizontal (A) and two diagonal (B and C) measurements were made on one side of a comb at Raison, while both of its sides were so measured at Nagrota (Fig. 2). On each side of the comb three measurements were made in three directions, in order to safeguard against any stretching of the cells which might have taken place in the hive. It may, however, be pointed out that only those combs were measured which did not show any sign of stretching to the unaided eye.

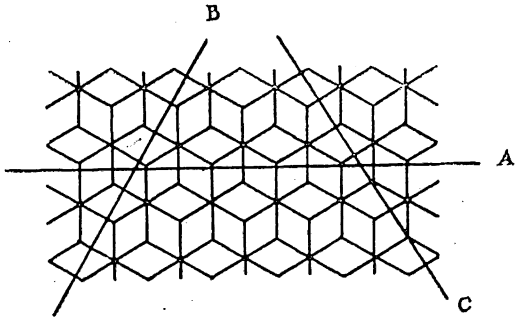

FIG. 2.—Direction of rows in which measurements were made.

DATA

Table I presents the results of 22 out of 162 combs measured at Raison. Table II gives the mean and standard deviation after compilation* of the figures in each group of measurements.

CONCLUSIONS

It is seen from Table I and the means given in Table II that a majority of the combs at Nagrota (3,000 ft.) had 22†, and at Raison (4,500 ft.) 21.25, cells to every four inches. The difference in the size of worker brood-cells in Nagrota and Raison combs is highly significant and shows that the worker bees found in and around the former locality are slightly smaller than those found in the latter locality. This shows that the variety of *Apis indica* found at higher altitudes, *e.g.*, Raison is larger than its

* This is also confirmed by observations made at Nagrota in 1936.

† In a few cases where it was not possible to measure the number of cells per four linear inches, due to the small size of the comb, though otherwise it was good and representative, a smaller number of cells was measured and then the number of cells in 4 linear inches was calculated therefrom to have uniformity.

TABLE I. *Number of worker brood-cells in nature at Raison (Number of combs measured =162).*

No. combs	DIRECTION OF MEASUREMENT						Number of cells in 4 linear inches			Method of measurement
	Ins.	No. of cells	Ins.	No. of cells	Ins.	No. of cells	A	B	C	
	A		B		C					
1	4	20.75	4	21.5	4	21.5	20.75	21.5	21.5	i
3	4	21.25	4	22	4	21.5	21.25	22.0	21.5	i
3	3.75	20	3.64	20	3.69	20	21.30	21.97	21.7	ii
7	3	16	3	15.75	2	10.75	21.30	21.0	21.50	i
7	2.83	15	2.87	15	1.84	10	21.20	20.87	21.7	ii
12	4	21.25	4	21	4	21.5	21.25	21.0	21.5	i
12	3.8	20	3.8	20	3.72	20	21.0	21.0	21.5	ii
15	4	20.5	4	21	4	21	20.50	21.0	21.0	i
15	3.87	20	3.8	20	3.8	20	20.64	21.0	21.0	ii
16	4	21.75	4	21.75	4	21.5	21.75	21.75	21.5	i
16	3.7	20	3.7	20	3.73	20	21.70	21.7	21.42	ii
44	4	20.5	4	21	2	10.25	20.5	21.0	21.0	i
44	3.9	20	3.83	20	1.92	10	20.56	20.9	21.81	ii
	mm.	No. of cells	mm.	No. of cells	mm.	No. of cells				
68	51.5	11	46.5	10	47	10	21.70	21.84	21.6	iii
76	95.5	20	96.5	20	80.5	17	21.27	21.06	21.45	iii
82	80.5	17	62.25	13	61.5	13	21.45	21.21	21.47	iii
98	96.5	20	99.5	21	96.5	20	21.05	21.44	21.05	iii
99	97.0	20	100.0	21	99.5	21	20.94	21.33	21.44	iii
110	95.5	20	81.0	17	95.5	20	21.27	21.32	21.27	iii
115	95.5	20	95.5	20	95.0	20	21.27	21.27	21.39	iii
131	95.5	20	96.0	20	96.5	20	21.27	21.16	21.05	iii
137	82.5	17	87.0	18	99.5	21	20.93	21.02	21.44	iii

TABLE II. *Number of worker brood-cells per four linear inches at Nagrota and Raison.*

Locality	Number of combs measured	Total No. of measurements	Period when measured	Direction of measurement	Mean	Standard deviation
Nagrota	73	432	April-July, 1938	A*	22.0023	±.2422
				B*	22.0062	±.2106
				C*	22.0152	±.2192
		Average	.....	.....	22.0079	±.2083
Raison	162	535	April-July, 1938	A*	21.248	±.4397
				B*	21.257	±.422
				C*	21.267	±.4334
		Average	.....	.....	21.2576	±.4498

* See Fig. 2 for explanation.

compatriot in the plains and submontane tracts, *e.g.*, Nagrota in the Punjab. This view is supported by the observations of Watt (1908) and Ghosh (1915).

In view of these figures it is evident that before buying the comb-foundation the intending apiarists should obtain exact information regarding the size of worker brood-cells, which the bees of the locality make in nature. This will ensure regularly constructed combs and better bee-keeping, and safe-guard against disappointments.

ACKNOWLEDGMENT

We are greatly indebted to Dr. Khan A. Rahman, Entomologist to Government, Punjab, Lyallpur, for his help in writing up this paper.

SUMMARY

A large number of combs of *Apis indica* F. were measured at Nagrota (Kangra Valley) and Raison (Kulu Valley) to find out the size of worker brood-cells. The bees make 22.0079±.2083 cells to four linear inches at Nagrota and 21.2576±.4498 cells at Raison as against 24.0 of *A. indica* in other parts of India and 19.3 of *A. mellifica*. The comb-foundation, therefore, for *A. indica* in different localities should be made according to the correct measurements of the worker cells of the natural combs of *indica* in different tracts.

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(*Received for publication on* 24. iii. 1940).

SHORT NOTES AND EXHIBITS

These are chiefly taken from reports of meetings held at the various branch centres of the Society.

Dasychira dehra Collnt. (Lymantriidæ)

The original description of *Dasychira dehra* Collenette (*Ann. Mag. Nat. Hist.*, 2 (10) : 382, 1938), was based on six specimens, all from Dehra Dun and all reared or taken on the wing between 25th December and 7th February, that is to say in the cold season. A subsequent rearing experiment suggests that *D. dehra* is a seasonal form of *D. grotei* Moore and Mr. Collenette tells me that details would be of interest especially as little appears to be known of the existence of seasonal forms in the Lymantriidæ.

D. grotei Moore, a species frequently referred to as *D. horsfieldi* Saund., (which name, however, according to Mr. Collenette (*in litt.*) should be applied to a distinct species from Java) is widely distributed in India and has many food-plants, the most important of which is *Shorea robusta*. The full-grown larva (*Indian For. Rec.*, 8 (10) : p. 197, 1938,) is typically pale sulphur-yellow, with long concolorous hairs but with a large black spot shared by the first and second abdominal terga. In some individuals the hairs are pale brownish.

D. dehra is, in the words of Mr. Collenette, closely related to *D. grotei* but distinguished in the male by the darker hind wing and almost unicolorous fore wing. The females of the two species resemble one another more closely. The larva is similar to that of *grotei*.

On 13th November, 1937 a larva (J. C. M. G. 4028) similar to *D. grotei*, was taken on leaves of *Terminalia crenulata* at Dehra Dun ; this pupated on 11th December and a moth emerged on 2nd February, 1938. The moth is a typical male of *D. dehra*. On 10th December, 1937 a similar larva (J. C. M. G. 4046) was taken on *Catalpa* sp. at Dehra Dun, in the act of making its cocoon. A moth emerged on 7th February, 1938. The moth is a female of *D. dehra*.

The male and female moths were put together and fertile eggs were laid between 9th and 12th February. Larvæ from these were fed on leaves of *Terminalia crenulata* ; twelve pupæ were formed between 11th and 22nd April and twelve moths emerged between 22nd and 29th April, the pupal period varying between seven and thirteen days, (compare the much longer pupal period of the parents). All these moths are typical *D. grotei*.

The conclusion is that *dehra* is a seasonal form of *grotei*. Two males, collected at Dehra Dun on 18th February, 1930 and 13 March, 1938 respectively, are in my opinion intermediate between the two species. Mr. Collenette tells me that Mr. Tams has carefully examined the genitalia of *grotei* and *dehra* and finds no difference.

J. C. M. GARDNER, *Dehra Dun.*

Occurrence of green algæ on the wings of locusts

In the course of a critical biometrical examination of large numbers of locusts to note the condition of development of the different parts of the body, their coloration and the presence of external parasites, at different times of the

year, it was noticed that colonies of green algæ were present among the folds of the hindwings in certain instances.

No statement can be made at present as to whether there is any organic relation between the colonies of green algæ and the locusts on which they are found, nor is there any indication as to how these colonies are transferred from one locust to another. Presumably air-borne spores bring about infection.

These algæ are not found on newly fledged locusts, but are most commonly found in over-wintered forms. Apparently the spores require a cool, moist, foggy atmosphere such as may be found in the cold weather in places full of vegetation, as is the case in certain parts of desert areas. Light rainfall in winter is probably conducive to the development of the algæ on wings.

The presence of the green algæ has sometimes been found to give rather valuable indication as to the breeding ground from which the locusts might have come, and as to the age of particular individuals.

Y. RAMACHANDRA RAO, *New Delhi.*

Habits of the Reduviid bug *Acanthaspis quinquespinosa* (Fabr.)

There are about forty species of the genus *Acanthaspis* recorded from India but not much is so far known about their habits. *A. quinquespinosa* Fabr. is a widely distributed species, previously recorded from Khasi Hills, Margherita, Ranchi, Saran, Poona, Bhore Ghat, Ceylon and Burma. In the Imperial Pusa Collection there are a few adults caught at light.

In October 1939, nymphs and adults of this species were noticed hiding under pieces of charcoal and coke lying on a floor and feeding on worker white-ants which had built their galleries in between and on the pieces of coke. In the laboratory, they were fed on white-ants and various caterpillars. Winter and early spring were passed as nymphs and adults. About the end of March, all the nymphs became adults and copulation and oviposition commenced. The pairs copulated frequently.

For catching its prey the predator bug darts forward and the victim is grasped by the front legs and pierced with the stylets of the rostrum at the same instant. Within a short period of half a minute or so, the prey is paralysed and then feeding may proceed at the will of the assailant. The front legs are not used to hold the insect after the struggle is over, instead the prey is held dangling from the tip of the rostrum. Feeding is continued until the liquid of the host's body is exhausted after which the carcass is thrown away.

The nymphs have the peculiar habit of disguising themselves by covering their bodies with various substances, which are held in place by sticky hairs present on their body. With each moult this material is thrown away and fresh material is gradually put on. GHULAM ULLAH, *New Delhi.*

Oviposition by moths subjected to cyanide "killing"

On 4th December, 1939 a specimen of *Euproctis lunata* Wlk. was placed, at about 3 p.m., in a cyanide killing-bottle for about twenty minutes and was then pinned and set in the usual way. Next morning though the moth showed no signs of life, it was noticed to have laid overnight a mass of about 20-30 eggs.

Similarly, a specimen of *Sphenarches cafer* Zell., placed on 8th February, 1940 in a cyanide killing-bottle for about fifteen minutes, and then pinned and

set, was noticed to have laid overnight five eggs though it was dead. A caterpillar hatched from one of these eggs, in spite of food being provided, died the same day.

Probably the moths revived for some time after being "killed" and set, during which period they might have oviposited, and died actually as a combined result of pinning, poisoning and exhaustion due to what little oviposition they could effect. It is a fact of common observation that insects may oviposit very soon after they are killed, but in the cases reported above it is noteworthy that quite a long time elapsed between "death" and oviposition.

SHUMSHER SING, *New Delhi.*

Toxicity of sodium silico-fluoride and barium silico-fluoride to locusts

Comparative toxicity of sodium silico-fluoride and barium silico-fluoride to hoppers of *Schistocerca gregaria* Forsk., bred in the laboratory at Karachi under crowded condition, was determined in September, 1938. In each case 15 hoppers were experimented with. The sets of hoppers used in the experiments were kept starved overnight and were then allowed to feed for about 6 hours on the bait prepared according to the following formula :—Bran 50 seers, molasses 2 seers (or salt 1 seer), poison 1 seer, water as required. After the specified period of feeding on the bait, the hoppers were transferred to new cages and fed on fresh lucerne on the subsequent days. The result is tabulated below :—

Date	Mortality with sodium silico-fluoride	Mortality with barium silico-fluoride	Mortality in control
23.IX.1938	1 (after two hours of feeding)	.....	Nil
24.IX.1938	6 (after about 24 hours)	1 (after about 24 hours)	Nil
25.IX.1938	5 (after about 48 hours)	7 (after about 48 hours)	Nil
27.IX.1938	1 (after 96 hours)	1 (after 96 hours)	Nil
Total	13 Mortality—86.6%	9 Mortality—60%	

Although the experiments need further repetition to be conclusive, it appears that the sodium fluosilicate is more effective as poison than barium fluosilicate against the desert locust.

S. MUKERJI, *Karachi.*

Hosts of *Phytomyza atricornis* in the Punjab

In the Punjab, this leaf-miner has been found on several ornamental plants such as cineraria, nasturtium, petunia, clarkia, verbena, poppy and hollyhock.

K. N. TREHAN, *Lyallpur.*

Alphitobius lævigatus Fabr. (Tenebrionidæ), as a household pest

Previously known to occur in store rooms in the Punjab, this beetle was recently noticed causing great nuisance in houses. It appeared in large numbers during night crawling on kitchen walls and falling into dishes and other utensils. The beetles were noticed coming out of cracks in the wall and congregating on the warm walls close to the fire place, indicating a certain amount of preference for heat. They seemed to shun light as they disappeared as soon as light was switched on.

K. N. TREHAN, *Lyallpur.*

Wandering habit of nymphs of *Drosicha stebbengi*

The nymphs of the mango mealy-bug seem to have great capacity for wandering about in search of suitable hosts. The habits of nymphs were studied by marking them with enamel paints and it was found that nymphs of first instar could crawl about 40 feet or so, while those of the last instar wandered away up to 150 feet. When sticky bands are put on the trunks of mango trees, the nymphs try several other trees, climb up and finally settle on various weeds at considerable distance from the banded trees. A. LATEEF, *Lyallpur.*

Stathmopoda trissorrhiza Meyr. (Heliodinidæ), in the Punjab

The insect was observed at Lyallpur and Kulu in the Punjab, feeding on stored *anab* berries (*Zizyphus* sp.). This is probably the first record of this species from India. The insect is active during summer, but in winter it hibernates as a larva inside the berries. It feeds on the dry pulp of the fruit and the damage is characterised by the presence of a thin whitish web, intervening the berries. GURCHARAN SINGH SOHI, *Lyallpur.*

Bryobia sp. (Acarina), on chrysanthemum in the Punjab

This species of mites infests the upper surface of chrysanthemum leaves, which consequently wilt and fall off. The mite tides over winter in the egg stage on foliage of the suckers. The eggs hatch towards the end of March. The activity is at its best during April-July, after which the monsoon rains wash them down and kill the active forms. Eggs are unaffected and produce the future progeny. All stages of this mite are available up to the beginning of November. A. N. SAPRA, *Lyallpur.*

Geomermis indica Stein., a new Nematode parasite of *Pempheres affinis* Faust.

In October 1937, the writer discovered for the first time, a minute thread-like worm, *Geomermis indica* Steiner * (Mermithidæ), in a full-grown grub of *Pempheres affinis* Fst., infesting the plant, *Triumfetta rhomboidea*, collected from Thondamuthur near Coimbatore. Externally the presence of these worms was not in any way indicated, save perhaps by the slightly inflated abdomen in an otherwise emaciated body, which sometimes acquires a dirty-pinkish tint. The parasitised grub had almost lost its white colour and appeared inactive and paralysed. When transferred to a drop of water, the worms exhibited slight wriggling movement.

The number of worm larvæ in a host varies greatly. In some cases, as many as 11-17 larvæ have been recovered from a single grub. The larval forms have been noticed in three different stages of growth. The earliest stage is a slender elongate form, with a bluntly pointed terminus, measuring 0.308 mm. in length and 0.0176 mm. in width. The second stage (Fig. 1) is much larger and measures from 0.462 mm. to 0.484 mm. in length, with an average width of 0.022 mm. The third stage larva is stouter and longer, measuring 0.704 mm. in length, with a width of 0.088 mm. The larva,

* The writer is indebted to Dr. Steiner for the identification of the parasite, which belongs to a new species and is the first record from outside the U.S.A.

particularly in early stages, is comparatively active and moves about quickly in a drop of water and coils itself like millipedes when water is withdrawn. They imbibe their nourishment from the fluid contents of the abdominal cavity. When full-grown, they effect their emergence by breaking through the intersegmental membrane in the abdominal region of the host, thus bringing about its death.

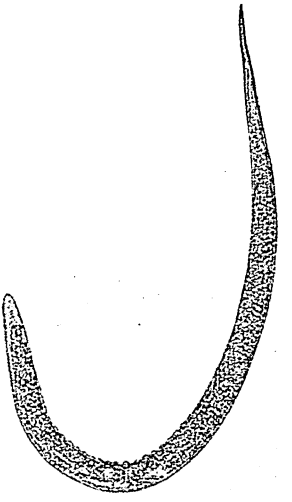

FIG. 1. *Geomeris, indica* Stein.

There are no records of Mermithids attacking Curculionids. Apparently *G. indica* is confined to the single host, *P. affinis*. Though the weevil attacks a variety of plants, the nematode has been recovered only in association with only *T. rhomboidea*. Recently one infested grub has been obtained from another plant, *Malvastrum coromandelianum*. The parasites occur only during the months of September, October and November; in rare cases they have also been recovered in December and in January.

Possible mode of infection.—From the occurrence of the parasite in autumn and winter, it is surmised that the adult female parasites are probably stimulated by rains to ascend up plants and deposit eggs thereon. The larvæ on hatching, seek young host grubs near the surface of stems or in superficial tunnels.

The economic value of Mermithids in the control of injurious insects has not been adequately appreciated, particularly in India. Their occurrence in diverse groups of insects and the injurious effect and ultimate mortality caused, have been recorded in other countries. In some cases the development of the host has been arrested, while in others sterility has been induced or fecundity diminished.

P. N. KRISHNA AYYAR, *Coimbatore.*

Oncocephala tuberculata Oliv. (Chrysomelidæ)

This beetle, previously recorded on sweet potato (*Ipomaea batata*), has been collected by us on *Ipomoea sepiaria* at Coimbatore. Under laboratory conditions, the maximum longevity of the beetle was 50 days. Eggs are laid singly on the leaves, thrust into their tissues. The egg is flat and ovoid in shape and is pale brown in colour but turns darker in three to four days. The egg period is seven to ten days. The newly hatched grub measures 1.2 mm. in length and 0.8 mm. in breadth. It is flattened dorso-ventrally and pale yellowish in colour, with pale brown head. The grub has eight spine-like projections on each side of the body. Soon after hatching, the young grubs mine the leaves and feed on the tissues. When the grub wants to come out of the leaf, it makes a crescent-shaped exit-hole and the same kind of hole is made when the grub wants to make a fresh mine. The affected leaves get dried up and wither. The full-grown grub is 8 mm. long and 2 mm. broad. When about to pupate, the grub comes out of the mine and selects a healthy leaf for pupation. A crescent-shaped cut is made and the grub makes a small tunnel, inside which it pupates. The larval period is seventeen to twenty-three days. The pupa is flat and naked and measures

5.8 mm. long and 3 mm. broad. The pupal period is eight to fifteen days. The total life-cycle from egg to adult stage is thirty-two to forty-eight days.

M. C. CHERIAN & KRISHNA MENON, *Coimbatore.*

Two interesting and unrecorded enemies of the palm beetle, *Rhynchophorus ferrugineus*

The palm beetle, *Rhynchophorus ferrugineus*, is undoubtedly the most common of the insects affecting coconuts in Cochin. The beetle breeds throughout the year. Any enemy of this pest must, therefore, be of great interest. The writer has come across the following two enemies, which he has not found recorded anywhere.

The adult beetles are infested by a sarcophagid, *Sarcophaga fuscicunda* Bott. This fly was first noticed by the writer in May, 1938, from beetles collected from the field. The parasitic grubs feed inside the beetles, and emerge out for pupation. In the laboratory, they pupate at the bottom of the breeding jars, but it has not yet been possible to come across the pupæ in the field. The adult flies emerge within a week after pupation. Healthy adults, without the least sign of internal injury or weakness, are found to harbour the larvæ inside their bodies. Affected beetles die in a few days, the larvæ coming out from their bodies for pupation.

The other enemy is a rodent of the genus *Bandicota*, which preys upon the fleshy grubs of the beetle. This rodent, called "*perichazhi*" in Malayalam is common throughout the State, and is a serious pest both in gardens, and homesteads. It was noted that the population of grubs in a manure heap was greatly reduced after a visit of one of these rodents. Careful observations showed that the animal rummages and spreads out the heap for finding the grubs breeding inside. A number of rodents have been imprisoned in cages, and fed with grubs. They not only take to the grubs readily and with great relish, but consume large quantities of them. There is no doubt that the rodent is a serious enemy of the grub, but the animal itself is a bad pest of gardens, especially of root crops.

C. S. VENKATSUBBA IYER, *Trichur.*

The mango Cecidomyid *Dasyneura mangiferæ* Felt, in Cochin

This Cecidomyid, *Dasyneura mangiferæ* Felt, is a serious pest of mango inflorescences in the Cochin State and in the last two seasons (1938 & 1939) infestation of buds by this insect reached 60—70%. The fly lays eggs inside a tender bud, generally only one per bud. The grubs, which are orange yellow in colour, feed on the reproductive parts of the bud. The attacked bud assumes a large, pointed and gall-like shape and thus can be easily distinguished in an inflorescence. The grubs pupate inside the buds. The adults, on emerging, leave the pupal skin as a white film-like membrane at the tip of the bud. The affected buds do not evidently grow and set into fruit.

C. S. VENKATSUBBA IYER, *Trichur.*

RECENT RESEARCH

Alimentary canal in the Coccinellidæ

The study of the anatomy and histology of the alimentary canal of various insects in correlation with the physiology of digestion has assumed great importance in recent years. Pradhan (*Q.J.M.S.*, 1939, **81** (3)) has contributed a paper on the alimentary canal of the coccinellid beetles, of both the herbivorous and carnivorous forms, including an account of the nerve supply to digestive organs and the extrinsic muscles of cephalic stomodæum.

In the carnivorous forms, exemplified by *Coccinella septempunctata*, no muscles are inserted on the cephalic stomodæum while in *Epilachna indica*, which is a herbivorous form, there is a pair of ventral dilator muscles inserted on the wall of the pharynx. The oesphageal nervous system is of a simple type, the frontal ganglion sending out anterior and posterior nerves. No ganglion is found along the course of posterior (recurrent) nerve.

The histology of the midgut epithelium and the processes of its regeneration have been investigated in detail. There seem to be different types of variations in the midgut epithelium. In the first type, in which they are contiguously arranged above and in between the nidi, the epithelial cells are either short or long and columnar. In the type in which the epithelial cells are separately grouped they either form a single layer, confined to the tops of the nidi or there are two layers formed over the nidi, the one adjacent to the latter, consisting of separate groups of large cells enclosing a big cavity. The author claims that the type mentioned last has been observed for the first time in insects. The cells adjacent to the nidi have been termed as pro-epithelial cells and the cavity which they enclose near their apices is named as pro-epithelial cavity. The author relates the mode of regeneration of the midgut epithelium by the pro-epithelial cells, which in reality represent some of the especially modified cells of the nidi themselves. Contrary to the common belief, the author holds that the basement membrane is found between the nidi and epithelium and not below the nidi.

A comparison of the alimentary canal of *Coccinella septempunctata* with that of *Epilachna indica* reveals a number of differences which the author has tried to explain on the basis of different types of food taken by the different forms of Coccinellidæ, which these two species represent. M.A.H.Q.

Structure and growth of insect antennæ

Last year Imms (*cf. Indian J. Ent.*, 1939, **I** (1 & 2) : 120) made an important contribution to our knowledge of musculature of insect antennæ. In a

recent paper on the growth of antennæ (*Q.J.M.S.*, **81**(4) : 585) this author concludes that the addition of new components in the segmented type of insect antenna, that of Campodea, is by means of acrogenous growth. The apical segment develops a furrow which, becoming more pronounced, demarcates a proximal area or a new segment. Continued growth of this kind results in the formation of further new segments, until the full number is ultimately acquired. The intrinsic muscles of the new segments are acquired as each segment becomes formed. New components in the annulated type of insect antenna are formed by the division of the second annulus or so-called 'third segment' from the base. In certain insects some, or all, of the remaining annuli also divide and thus give rise to additional annuli. It is also found that there is a positive correlation between the presence of "Johnston's organ" in annulated antennæ and its absence in segmented antennæ, which suggests that this organ is concerned with the perception of stimuli affecting the entire antennal flagellum. H.S.P.

Atmospheric moisture in relation to ecological problems

In order to clear the confusion, which still exists with regard to the relation between atmospheric humidity, saturation deficiency and rate of evaporation in reference to the study of syn-ecology, Thornthwaite (*Ecology*, **21** : 17-27) has reopened the subject for discussion. He has emphasised Leighly's conclusion, which has hitherto received insufficient attention, *viz.*, that the rate of evaporation is proportional to the vapour pressure gradient between the evaporating surface and the air.

It is well recognised that the maximum vapour pressure, as also the V. P. (vapour pressure) at any definite R. H. (relative humidity) rises with the rise in temperature. In order to be in equilibrium, water always evaporates from an atmosphere with higher V. P. to that at a lower V. P. and the rate of evaporation is proportional to the difference between the two vapour pressures (called V. P. gradient). A moist surface at 70°F (max. V. P.=0.7399″), when exposed to an atmosphere with 70% R. H. at 80°F (V. P.=0.7234″), will lose much less water (difference between two vapour pressures being small) than when exposed to the same R. H. (70%) at 60°F with a V. P. of 0.3654″. Thus, a surface of water at a given temperature (and therefore having a definite V. P.) will evaporate (if it does) more rapidly into a cooler atmosphere than into a warmer one of same R. H. ; or inversely, the higher the temperature of water surface, the quicker is the evaporation into a given atmosphere. Similarly, if the temperature and R. H. of air are such that its V. P. exceeds that of the water surface, moisture will move from the atmosphere to the water surface, in other words condensation will take place ; if V. P. of the water surface exceeds that of the air, evaporation will occur. It must be remembered that with the rise in temperature of air, its V. P. as well as saturation deficiency increase, but since the difference between its V. P. and that of the water surface (V. P. gradient) will decrease, the rate of evaporation will fall, in spite

of the rise in S. D. (saturation deficiency). Thus the S. D. of air has no bearing on the rate of evaporation when the temperature of evaporating surface remains independent of the atmospheric temperature. (This is however seldom the case among insects.) To illustrate this point the author gives an interesting example of evaporation from a large lake at 50°F. On a summer morning, let us suppose, the air is saturated at 50°F. Its V. P. will be 0.3626″. Since the V. P. of water surface is the same as that of the air, neither evaporation nor condensation will take place. As the air temperature rises in the day to 60°F, the R. H. will drop to 70%, the S. D. will rise from 0 to 0.159″ but V. P. will remain unchanged at 0.3626″. With the diurnal rise of temperature to 70°F, 80°F, and 90°F, the R. H. will fall to 49%, 35% and 26%, and the S. D. will rise to 0.3743, 0.6708 and 1.0608 inches respectively, yet no change in V. P. will take place so long as the quantity of water in the atmosphere remains same. Now, as long as the water temperature remains at 50°F, and its V. P. remains the same as that of the air above it, no evaporation will take place into the air in spite of the large S. D. set up there. However, the rate of evaporation will be directly proportional to the S. D. of the air when the temperature of the water surface changes with, and remains the same as that of the air (as it usually does among insects).

The author also discusses various measures of atmospheric moisture, such as the porous-bulb atmometer, evaporation pans, precipitation, etc., and points out their advantages and limitations. T.A.

Oviposition in relation to temperature

The previous work on the influence of temperature on various physiological processes in insects shows that whereas some processes like the rate of development, Co_2 production, oxygen consumption, etc., have a linear relationship with temperature within a greater portion of the temperature range, others are affected disproportionately by equal rises in temperature. Harries (*Ann. ent. Soc. Amer.*, **32** : 758-776,1939) has examined his own observations, along with those of previous workers on the rate of insect oviposition in reference to temperature and has analysed the whole data in the light of different temperature formulæ now in vogue for evaluating the accelerative influence of temperature on different biological processes. He concludes that the rate of oviposition and reproduction, although accelerated by a rise of temperature to a certain point beyond which it is retarded, is not proportional to temperature through any appreciable range so as to be represented by a straight line. The data examined follow S-shaped curves, similar to those found for several other physiological activities. The observed values of oviposition in relation to temperature when compared with calculated values according to the four well-known formulæ of Krogh, van't Hoff, Arrhinus, and Belehradek show maximum coincidence with van't Hoff's values. T.A.

Use of statistics in the taxonomy of insects

It is sometimes extremely difficult to distinguish two closely allied species on simple morphological characters. One way of separating them is to determine the ratios between the various organs of their bodies and to see whether the differences are significant. Such a study, employing statistical method, has been made by Johnson (*Trans. R. ent. Soc.*, **89** : 543-568,1940) on the pigeon-bug, *Cimex columbarius* Jenyns, and the common bed-bug, *C. lectularius* L., which resemble each other so closely that many workers have regarded them as one species. The most important character, which has hitherto been used for distinguishing them, is the difference in the proportion of the third and fourth antennal segments. After examining a large number of specimens of the two species, the author has found that the means of the ratio, length of 3rd/length of 4th antennal segments differ significantly, but their frequency distributions overlap completely. The 3rd and 4th antennal segments grow allometrically during development and their proportions vary according to the size of the adults. Environment will influence this ratio if it produces different sized adults. Adults of the same size of both the species will tend to have the same values for 3rd/4th antennal segments. This character is, therefore, of little use for taxonomic purposes.

A new and better distinguishing character, head-width/length of 3rd antennal segment has been found which enables a fairly satisfactory separation of the two species. The frequency distributions of this ratio for the two species overlap but slightly. The mean ratio for *C. lectularius* is 1.45± 0.08 and for *C. columbarius* 1.78 ± 0.10. This ratio does not vary with the size of the individual during development in *C. lectularius*, but it increases slightly with increase of head-width in *C. columbarius*.

In view of the foregoing and the fact that *C. lectularius* and *C. columbarius* produce fertile hybrids from the two reciprocal crosses, the author regards *C. columbarius* Jenyns as a subspecies of *C. lectularius* L. and therefore suggests that the species should be named as *Cimex lectularius* L. subspecies *columbarius* Jenyns and *Cimex lectularius lectularius* L. G.U.

Larval diapause in *Platyedra gossypiella* (Saunders)

It is well-known that the larvæ of *Platyedra gossypiella* (pink bollworm of cotton) exhibit a marked difference in the rate of their development, particularly towards the end of the cotton season. While some continue to develop rapidly and are, therefore, termed 'short-cycle' larvæ, others enter into a phase of extremely slackened development and emerge as adults after several months or sometimes after one or two years. The latter are not known as 'long-cycle' larvæ. The causes underlying the long-cycle phase are not well understood and it is often regarded as an instance of hibernation or æstivation.

In 1937, Squire (*Trop. Agric.*, **14** : 299) put forth the tentative view that the apparent hibernation in *P. gossypiella* was a case of diapause induced by

the dry condition of food at the end of the season, irrespective of the time of the year in which it took place. He has now confirmed these conclusions (*Bull. ent. Res.*, **30** : 475) by experiments. By determining the moisture content of cotton seeds he found that after the opening of the bolls, the seeds underwent slow desiccation and showed a decline in moisture content from about 80% on the day of opening to about 14% a week later. Larvæ experimentally fed on young buds and bolls containing a high percentage of moisture did not enter the resting stage, while those fed on seeds obtained from open (and presumably drier) bolls entered the long-cycle phase. He found that the percentage of larvæ entering diapause was inversely proportional to the extent of moisture in the food. He was able to terminate diapause by artificially wetting the environment of resting larvæ.

He concludes that as the crop ripens, the insect increases in numbers and more and more larvæ are forced to feed on nature bolls with low moisture content and thus enter into a phase of arrested or suspended development.

T.A.

Reaction of Acridids to light

Mass flights of locusts reared in large cages and their orientation to light have been observed by several workers, but the factors responsible for them have so far remained almost unexplored. In a recent contribution, Volkonsky (*Arch. Inst. Pasteur Algierie*, **17** : 194-220, 1939) describes observations on reaction to light in *Locusta migratoria* L., *Schistocerca gregaria* Forsk., and *Anacridium moestum melanorhodon* Wlk. His experiments show that the complete immobility of locust, with the body orientated at right angles or parallel to the rays of sun, was the combined result of heat and light perception.

The body temperature of *Schistocerca* and *Locusta*, exposed to the sun, exceeded that of the air by 16°–17°C when the body was at right angle and by 6°–7°C when it was parallel to the rays. The 'preferendum body temperature', which implies the temperature at which the locusts change their position in a cage, ranged from 35–36°C in the first instar hoppers to 41–42°C in *Schistocerca* adults and from 34° to 42°C in *Locusta*. It was lower by 1.5–2.5°C in phase *solitaria* than in phase *gregaria* in both the species.

Adults of *Schistocerca* and *Locusta* confined in big cages, containing some thousands of individuals, became occasionally active, flying frantically about the cage for several hours. Such mass flights alternated with periods of immobility, which were, according to the author, due to the effect of varying light and temperature. The activity was more marked if clouds appeared. Flights of short duration were also observed before sunset.

Mass flight was sometimes observed in the absence of any apparent external stimulus. In the case of *Locusta* such flights occurred at relative humidities usually below 59% and at body temperatures ranging from 35°–45°C at which the immobilising effect of light and heat was reduced.

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It follows from the above that, under natural conditions, voluntary flights of locust will depend on the degree of relative humidity and cloudiness, provided the temperature is suitable. As humidity below 60 per cent favours flight, the swarms will congregate in zones of higher humidity and will also leave the regions having heavy clouds. K.D.B.

Mechanism of feeding in mosquitoes

Previous investigations on the mechanism of feeding by mosquitoes have either been external observations on the act of biting or based on studies of mosquitoes killed during the act of feeding and subsequently sectioned together with portions of the tissue which they had pierced. Gordon and Lumsden (*Ann. trop. Med. Paras.*, 33 : 259-278) have described a technique by which observations were made on the mouth parts of *Aedes aegypti* (Linn.) while actually penetrating living tissues, and on the subsequent behaviour of the different parts when inside the tissue from which blood was being sucked. The authors have found that the mosquito repeatedly applies the tip of the labium to the skin before feeding, the labella being always kept pressed together and not separated as stated by previous workers. As the fascicle—a compound name given to the stylets—penetrates into the skin, the labium becomes increasingly kinked. This kinking of the labium and the protrusion of the tip of the fascicle, prior to the application of the labella to the skin, has not been observed by them. They, however, noticed that the labium, after feeding, does not immediately return to its normal position, and remains bent for several seconds before straightening to enclose the fascicle. An oscillatory cutting movement of the fascicle has been observed—the fascicle pierces into the tissue and works deeper into it, its progress being in a series of minute forward thrusts, after the manner of a pneumatic drill. They were not able to observe clearly the cutting movement of the maxillæ or of the mandibles, and it is not definitely known whether the movement of the stylets of the two sides is synchronous or alternate. They found that, far from being a rigid structure penetrating straight into the tissues, as is generally supposed, the fascicle is capable of bending to an extent which enables it to feel its way in any direction. Very often the tip of the fascicle was observed to curve sharply in the form of a 'J' and to search in the tissue in various directions. This purposive bending involved the distal fifth of the labrum and was more marked in the dorso-ventral plane. The rest of the fascicle appears to be passively flexible and able to accommodate itself to the curves previously pursued by the cutting tip. Two types of feeding—capillary and pool-feeding are described. In capillary-feeding, the blood is taken up directly from a capillary, the fascicle penetrating into its lumen. In pool-feeding, the tip of the fascicle comes to rest in a pool of blood derived from a previously lacerated capillary and sucks it up. A mosquito may take as long as ten minutes to become engorged when feeding by the latter method as against three minutes when sucking by capillary-feeding. They have shown that fluid, presumably salivary secretion, is injected into the tissues at various stages of penetration. I. M. P.

PROGRESS OF ENTOMOLOGICAL RESEARCH IN INDIA DURING 1939

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Entomological studies in India, as in many other countries, have centred largely round species of economic importance but of late there has been a drift towards broadening the basis of investigations and including in them species other than those which are injurious or useful to man. The requirements of the economic entomologist to have as full a knowledge as possible of pests under different conditions both in the field and laboratory and the desire of other workers, not primarily interested in pest control, to contribute to solutions of economic problems seem to produce cooperative researches, of which some examples will appear in the present review.

The year 1939 will remain memorable for the inauguration of the *Indian Journal of Entomology*, the official organ of the Entomological Society of India, and the first journal in this country to be devoted solely to all aspects of entomology.

MORPHOLOGY, ANATOMY AND HISTOLOGY

Pradhan (*Quart. J. micr. Sci.*, **81** : 451), has attempted a comparison between the herbivorous and carnivorous types of alimentary canals in Coccinellidæ. This work is discussed elsewhere in this journal (See Recent Research.)

The same author (*J. Morph.*, **64** : 47), has also shown that the conclusion of Snodgrass that ' labial glands are present in all the principal orders of insects except Coleoptera ' requires modification. He has given an account of the structure, probable function and segmental homology of the labial and other glands found in the head capsule of seven species of Coccinellidæ.

The correlation, noticed a few years ago, between the number of eye stripes in *Schistocerca gregaria* Forsk. and the number of moults undergone during the immature stage of this species has been confirmed by Rao and Gupta (*Indian J. agric. Sci.*, **9** : 727). These authors have also shown that eye stripes are present in many, though not all, genera of Acrididæ and wherever, information about the development of the species is available, the number of moults agree with the number of eye stripes.

Glover (*Indian J. Ent.*, **1**(3) : 1), has shown that the observed head-widths of the larvæ of *Aphrastobracon flavipennis* Ashm. (Braconidæ) of different instars correspond very closely to those calculated on the Dyar's principle. Further, the length of the larval mandibles in different instars increases in the same way as the larval head widths.

EMBRYOLOGY AND DEVELOPMENT

Roonwal (*Proc. nat. Inst. Sci. India*, **2** : 1), has amplified his theory of multiphased gastrulation in insects, originally proposed with reference to *Locusta migratoria migratorioides* Reiche and Frem., to make it applicable to nearly all

insects and several Arthropods. According to this theory, a true blastula does not occur in insects and gastrulation takes place in three main and several sub-phases, although the distinction between phases and sub-phases is often not sharp. Considered as a whole, multi-phased gastrulation is brought about by a combination of some of the known modes of gastrulation, *viz.*, emboly, epiboly, delamination and immigration. The similarity to insects in respect of three phased gastrulation can well be extended to Myriapoda, but only to a lesser extent to Crustacea, Arachnida and Onychophora.

A review of recent advances in insect embryology has also been published by Roonwal (*J. roy. Asiat. Soc. Bengal,* **4** : 17) which contains some interesting conclusions. For instance, in certain insects yolk cells are definitely believed to share in the formation of the mid-gut epithelium, the malpighian tubules have been shown to be of ectodermal origin ; the prolegs of Lepidopteran caterpillars are direct derivatives of the embryonic abdominal appendages and should hence be considered as true segmental appendages and so on. In reference to Hagen's classification of the various types of viviparity among insects, the author has proposed a further sub-division, namely, 'pseudoplacento-viviparity'. An historical account from the time of Aristotle and a bibliography of nearly 700 papers add greatly to the value of the review.

ECOLOGY AND BIOLOGY

For over two decades now there has been considerable speculation about the precise part played by the Braconid, *Microbracon greeni* race *lefroyi* in the control of *Earias insulana* Boisd. and *E. fabia* Stoll, the notorious spotted bollworms of cotton. As a contribution to the solution of this problem, Ahmad and Ghulam Ullah (*Indian J. Ent.*, **1** (1 & 2) : 17) have critically studied the rate of development and viability of the preimaginal stages of the host (*E. fabia*) and the parasite under different conditions of temperature and humidity. This work throws some light on the problem and, incidently, corrects or rationalises some old impressions. For instance, the observation that long exposures to 13°C or below in the laboratory prove equally fatal to both the species do not support the belief that severe winters are more injurious to the parasite than to the host. The upper vital limit of the host (40°C) is a little higher than that of the parasite (35°C), which means that while the host, specially its larval stages, can survive temperatures near about 40°C, the parasite cannot, a fact of great significance in determining the populations of the two species in nature, when the temperature in cotton bolls fluctuates between 35°C and 40°C. But between the upper and lower vital limits the parasite develops two and a half times faster than the host. In the matter of the egg, larval and pupal viabilities, the parasite seems to withstand high temperature better than the host, except in the pupal stage, when it is adversely affected by temperatures near 35°C. The moisture requirement of the parasite, namely, an almost saturated atmosphere, is more pronounced than that of the host and the pupæ of the former alone seem capable of standing some desiccation.

Experiments by Rahman and Sohi (*Indian J. Ent.*, **1**(1 & 2) : 57) have shown that the majority of grubs of *Trogoderma khapra* Arr. are unaffected by the light of a 30 watt Zeiss lamp until they are a day old ; later they become negatively phototropic, showing indifference to light only before and after moulting. Most of the males and females react negatively to light, in the case of the latter the number attaining its peak during oviposition period.

Locust (*Schistocerca gregaria* Forsk.) surveys in the desert areas of north-west India have been in progress since 1931 and evidence has accumulated to show that there is migration of the solitary phase individuals at different times of the year into different desert areas. Observations on two other locusts, *viz.*, *Patanga succincta* Linn. and *Locusta migratoria* Reich. & Frm. phase *solitaria*, taken during these surveys by Rao and Bhatia (*Indian J. agric. Sci.*, **9** : 79), show that the latter is also capable of long distance migration like *Scistocerca gregaria*. Further, *L. migratoria* differs from *S. gregaria* in definitely preferring a moist environment and food plants of the family Graminæ, which implies that there is possibility of concentrations of the former on crops, such as wheat and millets in the hill valleys, leading to crowded breeding and the outbreak of swarms. But the authors believe that the swarming of *Locusta* would, under the conditions of north-west India be a rather exceptional event.

How a change in the ecology of insects effected by man can determine their economic status is illustrated by the work of Haroon Khan (*Indian J. Ent.*, **1**(1 & 2) : 53). He has reported that certain mango orchards in Sind, which used to receive scanty water supply, had seldom had a severe infestation of *Idiocerus* spp. (Jassidæ). Recent extention of canals in the area, however, has ensured plentiful and frequent irrigation to the orchards, causing increased humidity therein and the greater vegetative growth of the plants. The result has been that the hoppers have become a pest but are as scarce as before in the neighbouring orchards getting scanty water supply as in old days.

Extremely few records of the fauna of hot waters of tropical countries, particularly India, are available. In June 1938, Pruthi (*Indian J. Ent.*, **1**(1 & 2): 65-67) collected specimens of two Hydrophilid beetles from a pond at Manali (6,000 ft.) in Kulu Valley, the water of which had a temperature of 45°C at 8 a.m. The chemical analysis of the water is also given.

Bhatia (*Indian J. Ent.*, **1**(1 & 2) : 49-51) has shown that there is a general coincidence between a rise or fall in the local population of the solitary phase individuals of the desert locust (not at times of breeding) and the occurrence of dust storms and strong winds in Sind-Rajputana.

Mahdihassan (*Curr. Sci.*, **8**(9) : 22) has recorded an interesting case of symbiosis between the ant *Polyrhachis rastella* Latr. var. *formicata* Ein. and the lac insect *Lakshadia mysorensis* growing on *Shorea tabura* in Bangalore. This is noteworthy in view the fact that ants of the genus *Polyrhachis* are known to build nests generally underground.

Faunistic and taxonomy

The Forest Entomologist, Dehra Dun, has been publishing biological notes on insects associated with forest trees in India. In the latest work of this series, Beeson and Bhatia (*Indian For. Rec., Ent.*, N. S., **5** : 1-235) have given information about 350 species of Indian Cerambycidæ. The dry wood borer, *Stromatium barbatum* Fabr., is mentioned as having the largest number of hosts (over three hundred) and *Shorea robusta* as being attacked by no less than 37 species of Cerambycidæ.

Sevastopulo (*J. Bombay nat. Hist. Soc.*, **40** : 381 ; **41** : 72 and 311) has helped to reduce the difficulty of recognising the immature stages of Indian Lepidoptera by publishing descriptions of their larvæ and pupæ, including

copious notes on colour markings. In the various papers of the year under review, several species of economic importance are included.

Our knowledge of the taxonomy of Indian Thysanoptera is largely due to the studies of Bagnall, Karney and Ramakrishna Ayyar. Two recent contributions, published by the last named author in collaboration with Margabandhu (*Rec. Indian Mus.*, **41** : 121 *& Indian J. Ent.*, 1(3) : 35) include notes on host plants, distribution and references to important literature on forty-six species. Of these, thirteen species and four genera are described as new, while six other species belong to genera not previously recorded from the Indian region.

For some time past doubt has existed as to whether the darker specimens of *Dacus ferrugineus* Fabr., occurring in the north-west India, should not be considered to belong to the variety *dorsalis* Hendel. Munro (*Indian J. Ent.*, 1(1 & 2) : 101) after an examination of material from India, consisting of typical *ferrugineus*, darker forms suspected to be the variety *dorsalis* and forms intermediate between these two, has come to the conclusion that the specimens are all referable to *D. ferrugineus*, and such colour variations as occur are not indicative of any abnormality or differences in functional and sensory reactions. The author considers that the variety *dorsalis* had better be reserved for specimens from Formosa.

Two Braconids, *Micrabracon lefroyi* (D. & G.) parasitising chiefly species of *Earias* in north and western regions of India and *M. greeni* Ashm., parasitising *Eublemma amabilis* Moore, chiefly in Bihar and Orissa, have long been regarded as distinct species and have attracted the attention of workers on the biological control of the bollworms of cotton and the predator enemies of the lac insect respectively. These species have been found to be identical in structure by Lal (*Curr. Sci.*, **8** : 125), but in view of some obvious differences in their biology, this author has regarded them as two biological races, *lefroyi* and *greeni* of the single and older species, *M. greeni* Ashm. Among a number of other new Braconid species, Lal (*Indian J. Ent.*, 1(3) : 49) has described *Rhaconotus roslinensis*, which is the second named species of this genus to be recorded attacking *Scirpophaga* sp., and the third to be known from India.

Mani's (*Indian J. Ent.*, 1(1 & 2) : 69) recent paper dealing with thirty-five species of parasites (mainly Chalcidoid) bred in different parts of India, may well form a supplement to his earlier contributions on Chalcidoidea (Catalogue of Indian Insects, No. 23), though for a complete up-to-date knowledge of the subject a few more papers will have to be taken into account. During the year under review, about two dozen species and several new genera have been described by Mani and a new sub-family, Bruchobinæ of Miscogasteridæ has been erected to include the genera *Bruchobius* Ashm. and *Oedaule* Waterston. An interesting genus recorded for the first time from the Indian region is *Pachyneuron*.

Beeson (*Indian For. Rec.*, N. S., *Ent.*, **5** (3): 279) has described under the fruit and bark-boring genera, *Coccotrypes* and *Thamnurgides*, 22 new species from India, Burma, Indo-China, Federated Malaya States, Ceylon and Java.

Gardner (*Indian For. Sec.*, N. S., *Ent.*, 6(1) : 1) describes 15 new species of Indian Cerambycidæ from 13 host trees.

Corporaal (*Indian For. Rec.*, N. S., *Ent.*, **6** (2):17) gives an annotated list of 72 species of Cleridæ bred or collected by the Forest Entomologist, India and Burma with data on distribution and species of trees attacked by borers preyed upon by Cleridæ.

Control of insects injurious to forest trees and crops

For some time past the biological control of insect pests of forest trees has engaged the attention of workers in India and Burma, and during the year under review considerable information on the biology and distribution of the parasites of teak defoliators together with observations on the results of experiments in the transport, liberation and effectiveness of some of them, have been published. The list given by Garthwaite and Desai (*Indian For. Rec.*, N. S., *Ent.*, **5** : 309) includes 116 species of parasites attacking *Hapalia machaeralis* Walk. and *Hyblaea puera* Cram. in Burma, and of these 53 are hyperparasites. The Braconid, *Apanteles machaeralis* Wilk., is well distributed in the forests of India and Burma, and in the latter has been known to parasitise *H. machaeralis* to the extent of 26%. It also accounts for 80% of the total parasitism of *H. machaeralis*. Still the high percentage of hyperparasitism from which *A. machaeralis* suffers in nature greatly reduces its value as an effective parasite. Another Braconid, *Cedria paradoxa* Wilk., parasite of the same host, however, which was introduced from India in 1937, seems to have bred in Burma under natural conditions. This species was also liberated in 1937 in mulberry plantations at Changa Monga (Punjab) for the control of *Margaronia pyloalis*.

Garthwaite (*Indian For. Rec.*, N. S., *Ent.*, **5** (2) : 237) reports that *Calopepla leayana* Latr. (Chrysomelidæ) feeding on the leaves of *Gmelina arborea* was a main factor responsible for the abandonment of 2,000 acres of plantations of this species at Namtu in the Northern Shan States, Burma. The egg, larval, pupal and adult stages are described and illustrated. *Brachymeria* sp. is a common pupal parasite and *Tetrastichus* sp. an egg parasite, the life histories of which are discussed. Mechanical methods of control, hand-picking and trapping proved ineffective in checking the beetle.

Beeson and Chatterjee (*Indian For. Rec.*, N. S., *Ent.*, **5**(5) : 357) give additional data on distribution, hosts, life-cycles, etc., of 23 hymenopterous and 6 dipterous parasites of teak defoliators in India. Experiments in the introduction and colonisation of parasites between Burma and India and *vice versa* are described.

In *Indian For. Rec.*, N. S., *Ent.*, **5**(6) : 381, P. N. Chatterjee, presents the biology and morphology of *Apanteles mechaeralis* Wilk.

Glover and Gupta (*Indian J. agric. Sci.*, **9** : 523) have examined the practicability of employing two important Braconid parasites, *Microbracon greeni* Ashm. race *greeni* and *M. hebetor* Say. for the control of the important predators of the lac insect. Both the parasitic species are reported to hold promise of control provided their populations can be kept up by artificial releases in the field during certain times of the year. The race *greeni*, on an average, parasitises 10% of the caterpillars of *E. amabilis*, but its population fluctuates from time to time depending on the viability of the host. *M. hebetor* is said not to occur in the major lac growing areas and had to be imported from Ceylon. Nevertheless its breeding in the laboratory seems easy and observations on initial releases appear to indicate that it can colonise and breed under field conditions near Ranchi and other lac growing areas. Ghulam Ullah (*Indian J. Ent.*, **1** (1 & 2) : 111) has, however, found this species parasitising *Antigastra catalaunalis* Dup. at Delhi and was able to breed it from *Earias insulana* Boisd., *E. fabia* Stoll, *Platyedra gossypiella* (Saund.) and *Phthorimaea operculella* Zell. Glover (*Indian J. Ent.*, **1**(3) : 1) has also studied the possibility of employing another Braconid, *Aphrastobracon flavipennis* Ashm., in the control of *E. amabilis* but has found it difficult to breed the parasite in the laboratory.

Rahman (*Indian J. Ent.*, 1(3) : 97) has testified to the success achieved in controlling the wooly-aphis, *Eriosoma lanigerum* (Haus.) in the Kulu Valley and Simla Hills, Punjab, by the introduction of its parasite, *Aphelinus mali* Hald., obtained from England.

In a paper on the economics of field-scale spraying against the whitefly of cotton (*Bemisia gossypiperda* M. & L.), Husain, Trehan and Verma (*Indian J. agric. Sci.*, 9 : 109) have published some data which should be useful in relation to other pests also.

Rahman and Nath (*Indian J. Ent.*, 1(3) : 25) have studied the bionomics of *Macropes excavatus* Dist. (Lygaeidæ), a pest of sugarcane in the Punjab, and state that the multiplication of this insect has been greatly helped by the practice of ratooning of Coimbatore varieties of cane.

Pruthi and Nigam (*Indian J. agric. Sci.*, 9 : 629) have shown that *Poecilocerus pictus* Linn. (Acridiidæ) hitherto known to attack wild plants of the genus *Colotropis* can readily take to feeding on such cultivated plants as brinjal, tomato, castor, etc., especially when its favourite food plant is not available and may well, therefore, be considered a potential pest. This work also shows how the successful use of an insecticide depends on the habits of the pest concerned. Sodium fluosilicate is well known to be very suitable poison for baiting locusts and other Acridids. Janjua (*Agric. Livestock India*, 9 : 688) has also found sodium fluosilicate to be very effective against the black-headed cricket, *Gryllulus domesticus* (Linn.). But poison baits with this insecticide proved useless against *Poecilocerus pictus* Linn., because of the habit of the grasshopper to remain largely on the plants and seldom come to the ground. Therefore, the authors have recommended spraying the food plants with sodium arsenite.

Discussing the control of the Dynastid *Oryctes rhinoceros* Linn., one of the three major pests of coconut palms in south India, Cherian and Anantanarayanan (*Indian J. agric. Sci.*, 9 : 541) consider the infection of the beetles with green muscardine fungus to be a promising remedy in view of the success achieved with this method in destroying larvæ of the beetle in their breeding places in Ceylon.

Pruthi and Narayanan have made (*Indian J. Agric. Sci.*, 9(1) : 15-37) a statistical study based on two years' data of the loss caused by moth borers and termites to mature sugarcane at Pusa. The top borer was found to be the most common, but the stem borer seemed to be comparatively more harmful, especially in decreasing the sucrose content of the infested cane. The root borer, in spite of its high incidence, did not seem to cause any damage in regard to weight or deterioration of sucrose content of the infested cane. Thus the extent of infestation did not afford a reliable criterion of the actual loss caused by various species. Of the various varieties examined, Co. 299 proved to be the most resistant and Co. 210 most susceptible.

The knowledge of phytophagous Chalcidoidea has grown comparatively recently. In India, besides the fig-insects, only two species are so far known, *viz.*, *Bruchophagus mellipes* Gahan, feeding on *agathi* and *Sesbania aegyptica*, and *Eurytoma samsonovi* Vasiljev, attacking apricot, the latter being more important. Pruthi and Batra (*Indian J. agric. Sci.*, 9 : 277), have given an account of the life history, nature of damage by and control of *E. samsonovi*, and point out that this chalcid is not known from any other part of India.

Cherian and Kylasam's studies (*J. Bombay nat. Hist. Soc.*, **41** : 253) on the biology of *Laphygma exigua*, a pest which seriously damages young nursery plants of tobacco in South India, have shown this species to occur in association with *Plusia signata* F. and *Prodenia litura* F. (Noctuidæ). But while in some beds, the latter two species predominated, in certain others the reverse was the case. For this no explanation is yet available. The authors suspect that the pest is carried over in off-season by a sand dune weed, *Gisekia pharnaceoides* L., which acts as a source of infection to tobacco.

The Amarantus borer, *Lixus truncatulus* (F.) is widely distributed in India as a pest of several species of *Amarantus* cultivated for vegetable, medicinal or ornamental purposes. Ahmad (*Indian J. agric. Sci.*, **9** : 609) has shown that a single host plant may harbour as many as 155 individuals of different stages and there may be at least three generations from March to November. Furthermore, the life of the adult may vary greatly from 9.2 days under conditions of starvation to about six months when food is available.

INSECT CARRIERS OF ANIMAL DISEASES

As a result of a survey of the warble flies, *Hypoderma lineatum* and *H. crossii*, made in the North-West Frontier Province, Chadha and Soni (*Indian J. vet. Sci.*, **9** : 101) have found that during the fly season 50 to 100 per cent of cattle and goats in certain areas bear tumours, the incidence of *H. lineatum* being heaviest in Dera Ismail Khan and that of *H. crossii* in Kohat and Hazara districts. Tumours are observed from October to February in the plains and from September to March in the hills. The annual loss to the hide industry on account of warble pests has been estimated at about four and a half lakhs of rupees, more than half of which is due to *H. lineatum*.

Sen (*Indian J. vet. Sci.*, **9** : 342) has shown that a spray consisting of high speed Diesel oil, pine oil and "pyrocide 20" does not cause burning or scurfing of skin of cattle and at the same time is very effective against *Musca crassirostris* and *Lyperosia exigua*.

Although, during the last few years Covell and Mehta have indicated the flea as a natural vector of certain typhus-like fevers, the possibility of the tick being also a vector remains to be tested. For this it is necessary to know the tick species which are found in association with man. Strickland and Roy (*Indian J. med. Res.*, **27** : 251) have listed a number of such species of the genera *Amblyomma, Rhipicephalus, Dermaceutor, Ixodes, Haemaphysalis* and *Hyalomma*.

The high incidence of sand-fly fever in Peshawar during the hot weather is a problem of considerable importance. Anderson (*Indian J. med. Res.*, **27** : 537) has found that persons coming from outside the sand-fly areas are more susceptible to this fever. As the sand-fly is capable of flying up to a height of 70 feet, persons sleeping on upper stories do not enjoy any protection from its bites. Spraying the rooms with 'Lethane (384)' has been found efficient in repelling the fly for twelve hours.

Covell and Afridi (*J. Mal. Inst. India*, **2** : 1, 315) have given a detailed account of the problems associated with mosquito breeding. With reference to the anti-malaria campaign in Delhi carried out during the last three years, the extensive use of a mixture of Diesel oil and cresol as a larvicide and 'Pyroxide 20' for spraying against adult mosquitoes in dwelling places have been found effective.

In South Travancore, Mathew (*J. Mal. Inst. India*, 2 : 101) has shown that *Anopheles fluviatilis* is an efficient malaria carrier. The same species has been found by Covell and Harbhagwan (*J. Mal. Inst. India*, 2 : 341) to be the only carrier in Wynad Taluk, S. India. Iyenger (*J. Mal. Inst. India*, 2 : 105) has shown that in Bengal *A. philippinensis* in the plains and *A. minimus* in the fort-hill areas are the most important vectors. Senior White and Adhikari (*J. Mal. Inst. India*, 2 : 395) have recorded *A. sundaicus* as malaria vector in the Chilka lake Islands. Roy and Majumdar (*J. Mal. Inst. India*, 2 : 243) have studied mating and egg-formation in *Culex fatigans* in the laboratory. A blood meal alone has been found sufficient for egg-formation, the shortest period elapsing between a blood meal and oviposition being about three days.

Manson (*J. Mal. Inst. India*, 2 : 85) has found that extracts of *Durranta, Zanthoxylum, Gardenia* and *Tephrosia*, particularly of the last named, have good larvicidal action *Anopheles minimus* in Assam. Russel and Jacob (*J. Mal. Inst. India*, 2 : 273, 293) have obtained good results with the fish *Gambusia affinis* in the control of *A. culicifacies* in certain parts of Madras Presidency.

During the last ten years considerable information has been acquired regarding the effects of environmental and other factors on the transmission of filariasis by *Cutex fatigans* in India and China. In this connection Basu and Rao (*Indian J. med. Res.*, 27 : 233) have studied the precise influence of temperature, humidity, etc. A very small percentage of mosquitoes become infected with the parasite at 60°F and 70-100 % R. H. but there is cent per cent infection at 90° F, R. H. remaining the same, and there is again no infection if the R. H. is lowered to 50-70 per cent, though the temperature may be 90°F. The age of the donor is also important in mosquito infectivity.

INSECT VECTORS OF PLANT VIRUSES

Further studies by Pruthi and Samuel on the white-fly (*Bemisia gossypiperda* M. & L.) vector of leaf-curl disease of tobacco in Bihar (*Indian J. agric. Sci.*, 9(2) : 223) have brought to light a dozen wild and cultivated plants near Pusa suffering from some form or other of leaf-curl disease and infested by the white-fly. Of these, the most important are sann-hemp and a weed, *Ageratum conyzoides*. This fact coupled with the experimental evidence that the white-fly does not readily transmit the disease from infected to healthy tobacco plants has led the authors to suggest that the source of leaf-curl infection lies outside this crop and a promising line of control of this disease should be the suppression of the white-fly population rather than the eradication of the alternate hosts of the virus.

It is now nearly ten years ago that a large scale survey of the insect fauna of sandal plantations in South India was carried out with the object of discovering the insect vector or vectors of the spike disease of sandal. Chatterjee (*Indian J. Ent.*, 1(3) : 15) gives an account of the various species and families of insects moving about in sandal plantations during day and night, and of the methods that may be employed in capturing them. The recent census has helped to enumerate some species as likely culprit, which the author has brought down to eleven. Although thrips were caught in the largest numbers, experimental evidence incriminating species of this order was practically nil.

NEW BOOKS & MONOGRAPHS

Meadow and pasture insects. By Herbert Osborn, assisted by Mrs. D. J. Knull. Pp. viii+288. Columbus, Ohio : Educators' Press, 1939. Price $3.75.

Principles of forest entomology. By S. A. Graham. 2nd. edition. Pp. xvi+410, 165 figs. London : McGraw-Hill Publishing Co., 1939. Price 24s.

Medical entomology with special reference to the health and well-being of man and animals. By W. B. Herms. 3rd. edition. Pp. xxi+582, 196 figs. London Macmillan & Co., 1939. Price 24s.

The social life of animals. By W. C. Allee. Pp. xiv+265, 5 pls., 49 figs. London : Heinemann & Co., 1939. Price 12s. 6d.

German-English science dictionary for students in agricultural, biological and physical sciences. By Louis De Vries. Pp. x+473. New York : The McGraw-Hill Book Co., 1939. Price $3.00.

An introduction to genetics. By G. W. Beadle and A. H. Sturtevant. Pp. xxiii+391. Philadelphia : W. B. Saunders Co., 1939. Price 14s.

A laboratory guide to entomology. By Robert Matheson. Pp. 135. Ithaca : The Comstock Publishing Co., Inc., 1939. Price $2.00.

Quantitative Zoology. By G. G. Simpson and Annee Roe. Pp. xvi+414. New York : The McGraw-Hill Book Co., Inc., 1939. Price $4.00.

Life and environment. By P. B. Sears. Pp. xx+175. New York : Bureau of Publications, Teachers' College, Columbia University. 1939.

World economic review of insecticides and allied products. Pp. xiii+149, foolscap, mimeographed. London : O. W. Roskill & Co. (Reports), Ltd., 1939. Price 100s.

The louse : An account of the lice which infest man, their medical importance and control. By P. A. Buxton. Pp. ix+115. London : Edward Arnold and Co., 1939. Price 7s. 6d.

Contribution á l'étude d'une espece : Apterina pedestris Meigen (Diptére). (Supplé-ments au *Bulletin biologique de France et de Belgique*, Supplément 26). By Jean Guibe. Pp. 112, 3 pls. Paris : Laboratoire d'évolution des etres organisés, 1939. Price 50 fr.

The invertebrates : Protozoa through Ctenophora. By L. H. Hyman. Pp. 708, illus. London : McGraw-Hill Publishing Co., Ltd., 1940. Price 40s.

British blood-sucking flies. By F. W. Edwards, H. Oldroyd and J. Smart. Pp. viii+156, 64 figs., 45 pls. London : British Museum (Natural History), 1940. Price 15s.

Animal life in fresh water. By Helen Mellanby. Pp. viii+296, 211 figs. New York : Chemical Publishing Co., 1940. Price $3.50.

Ce qu'il faut Savoir des insectes. Vol. II, Coléopterés et Hémiptéres. By G. Portevin. Pp. 307, 100 figs., 14 pls. Paris : Paul Lechevallier, 1940. Price 40 fr.

A method of illustration for zoological papers. By H. G. Cannon. Pp. x+36, 15 figs. London : Association of British Zoologists, Imperial College of Science and Technology, South Kensington, 1939. Price 3s.

Modern science. By H. Levy. Pp. x+736. New York: Alfred A. Knopf, 1939. Price $5.00.

Report on insect pests of crops in England and Wales, 1935-1937. *Bull. Minist. Agric. and Fisheries*, No. 118. Pp. vi+64. London: H. M. Stationery Office, 1939. Price 1s.

Termite damage: preventives and remedies. By W. J. Baerg. *Bull. Arkansas agric. Exp. Sta.* No. 385. Pp. 27. Fayetteville, Arkansas: Agricultural Experiment Station, 1940.

Fossil Orthoptera Ensifera. By F. E. Zeuner. Brit. Mus. (N. H.), 1939. Two vols. (one of text and one of plates).

A laboratory introduction to animal ecology and taxonomy. By O. Park, W. C. Allee and V. Shelford. Pp. 233; The University of Chicago Press: 1939.

The North American bees of the genus Osmia (*Hymenoptera: Apoidea*). By Grace H. Saidhum. *Mem. ent. Soc.*, 167 pp., Work No. 1, 278 fig.

NEWS AND ANNOUNCEMENTS

The scheme for the survey of the San José Scale in the North-West Frontier Province and the Punjab came to a close on the 31st March, 1940.

Rao Bahadur Y. Ramachandra Rao, M.A., Locust Entomologist, Imperial Council of Agricultural Research, New Delhi, has been elected President and Dr. P. Sen of the Public Health Department, Bengal, Recorder of the Section of Entomology of the Indian Science Congress, to be held at Benares, in January 1941.

At a joint meeting of the Zoology and Entomology Sections of the Indian Science Congress, held during its session at Madras in January 1940, a resolution recommending to the Indian universities, the desirability of devoting greater attention to the study of entomology both in the degree and the post-graduate classes was passed by an overwhelming majority.

Dr. M. L. Bhatia, Ph.D. (Cantab.), has been appointed Entomologist, Department of Agriculture, Bihar, Sabour.

Due to the war, the publication of the *Fauna of British India and Ceylon* has been suspended.

Dr. W. D. Funkhauser of the University of Kentucky, has been elected President of the Entomological Society of America for the year 1940.

Dr. C. F. C. Beeson, Forest Entomologist, is publishing a book on Forest Insects of 500—600 pages (price between Rs. 10/- and Rs. 12/8/-). Members of the Entomological Society of India can get the book at the concession price, if they inform the author before July, 1940.

Obituaries

Rai Bahadur C. S. Misra (1880-1939)

The news of the death of Rai Bahadur Chandra Shekar Misra on December 22nd, 1939, at Benares was received with profound sorrow by all entomological

workers in India and specially those of the Imperial Agricultural Research Institute, where he had served for over thirty years.

Mr. Misra was one of the earliest of the pioneer band of Indian workers on entomology. He began his work under the late Mr. H. Maxwell-Lefroy at the newly founded Agricultural Research Institute at Pusa in May, 1905. Born in July 1880, Mr. Misra took his B.A. degree from the University of Allahabad and for sometime worked as a science teacher in Raipur, C.P., before he was selected by Lefroy as his first assistant. This may explain why Mr. Misra was as good a teacher in entomology as he was a successful research worker. Some of the present provincial entomologists of India will recall with pride having received their first lessons in Entomology from the late Mr. Misra.

Mr. Misra carried out many detailed investigations on the fruit pests of India and was specially interested in several groups of Homoptera. He travelled throughout India to collect and study these insects in their natural habitats. He also did poineer work on the lac insect at Pusa and the bulletin on 'The Cultivation of Lac in the Plains of India' has been very useful and highly appreciated by all workers. In November, 1925, he went to Ranchi to organise the Section of Entomology in the newly opened Lac Research Institute. He returned to Pusa from Ranchi in April 1927 and, since then up to his retirement in July 1935, carried on his work most assiduously and published a number of very valuable papers on a variety of insects.

A perusal of the volumes of the *Entomological Bulletins* and *Memoirs of the Imperial Agricultural Research Institute*, the *Agricultural Journal of India*, the *Indian Journal of Agricultural Science* and the *Journal of Agriculture and Live-stock in India* show what a prolific writer the late Mr. Misra was. The proceedings of the various entomological meetings, held at Pusa, contain numerous interesting and valuable observations made by Misra on various insects.

His enthusiastic work for the advancement of entomology and his substantial contributions towards the enrichment of the science were duly recognised by the Government of India by the confirment of the title of Rai Bahadur on him in 1923.

Rai Bahadur C. S. Misra was known as a great disciplinarian and both his senior and junior colleagues had very great regard for him. His death is undoubtedly a great loss to Indian Entomology. B. B. Bose

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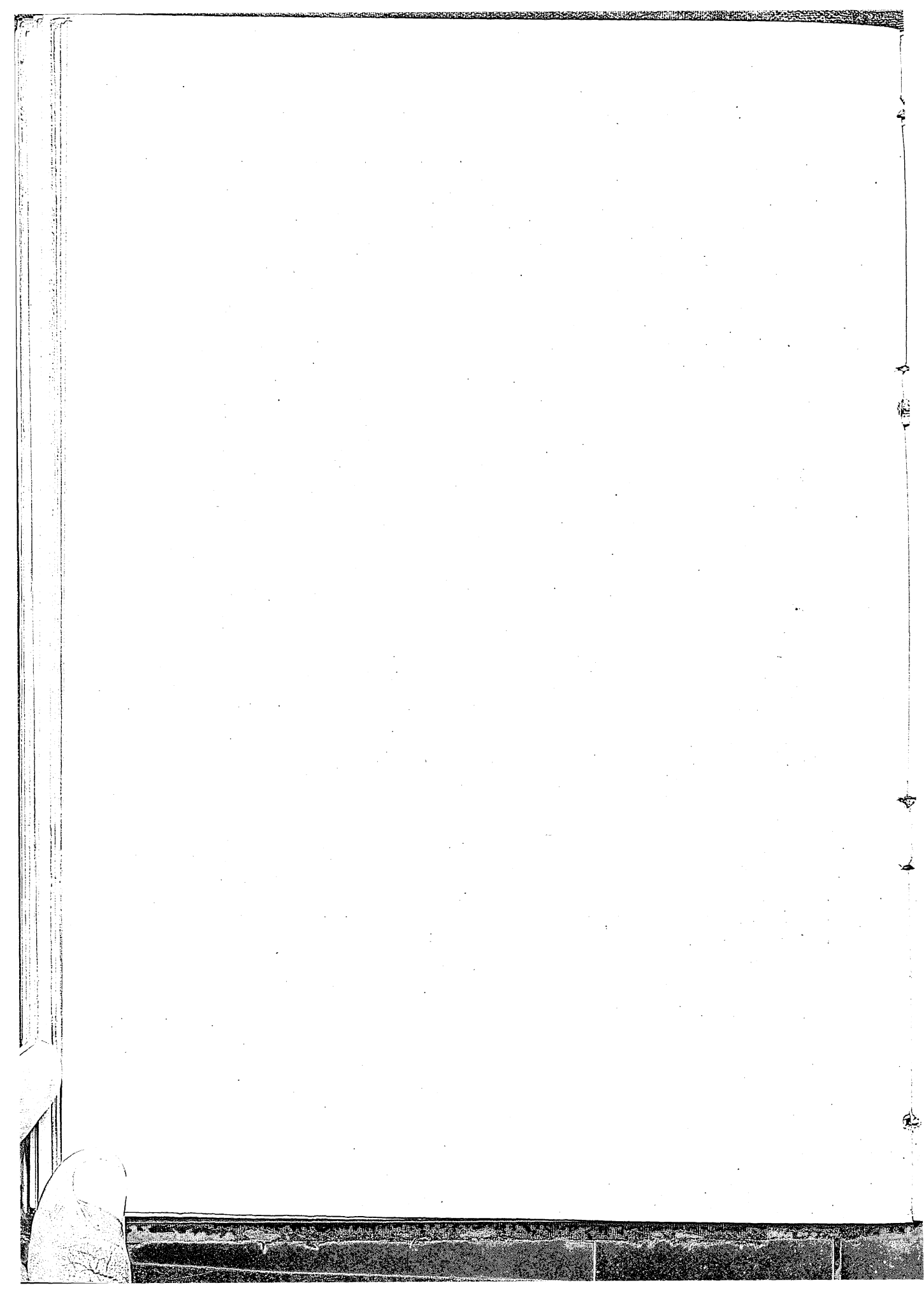
Dr. Royal Norton Chapman died after a brief illness on the 2nd December, 1939, at the age of 50. His text-book on 'Animal Ecology' has received world-wide recognition and his papers on the population of insects are well-known to entomologists.

Charles Nicolas Ainslie, Entomologist in the United States Department of Agriculture, 1906-30, died on the 5th December, 1939, at the age of 83.



PROCEEDINGS OF

THE ENTOMOLOGICAL SOCIETY OF INDIA

Minutes of the Second Annual General Meeting

The second annual general meeting of the Entomological Society of India was held at Madras on the 3rd January, 1940 from 2.30 to 4 p.m. and on the 4th January from 12.30 to 1 p.m. Owing to the unaviodable absence of the President, Mr. M. Afzal Husain, Dr. Hem Singh Pruthi, Vice-President, presided.

The minutes of the first Annual General Meeting held at Lahore were read and confirmed.

The following report on the working of the Society during 1939, including a statement on its financial position and a report of the auditor thereon, was read by the Secretary and unanimously adopted, on a porposal by Mr. P.M. Glover.

General Secretary's Report for 1939

At the end of 1938, the total membership of the Society was 42 Ordinary members and 2 Associate members. During 1939, 48 more members were enrolled, bringing the total for the year to 92, including 2 Life and 2 Associate members.

Three more branches of the Society have been started:—(1) South Indian Branch with headquarters at Coimbatore, (2) Bengal Branch with headquarters at Calcutta, and (3) Bihar Branch with headquarters at Pusa. It is hoped that very soon a branch will come into existence at Dehra Dun in the United Provinces.

Altogether 16 meetings were held under the auspices of the Society at its branch centres. The papers read in these meetings and other observations made, related both to applied and pure aspects of entomology.

The outstanding event of the year was the production of the *Indian Journal of Entomology*, the first two parts of which appeared (in one issue) about the middle of July and the third part, which would complete the volume for the year, is now in press and will appear very shortly. The Journal has been well received by entomologists and others both in India and abroad and has been appreciatively noticed in such journals, as the *Current Science* and the *Nature*. The question of the election of the Fellows of the Society, a resolution to which effect was passed in the last meeting held at Lahore, could not be taken up this year and has since been held in abeyance. It seemed that the opinion amongst members of the Selection Committee, appointed for the purpose, was divided and on reference to this Committee being made, it was found that the best course would be to postpone the consideration of this question for the Annual General Meeting to be held at Madras. This question is also coming up before this house presently.

The following is a statement of the accounts of the Society for 1939 :—

Receipts				Payments			
Admission fees and subscriptions ..	1,207	3	0	Printing of the 1st issue of the Journal ..	520	0	0
Advertisements ..	155	0	0	Despatch, postage, wrappers, etc. ..	123	11	6
Subscriptions for the Journal	90	0	0	Expenses at Branch centres ..	26	15	0
Brought forward from last year	747	12	6	Expenses at head-quarters ..	84	7	0
				Total ..	755	7	0
				Balance to the credit of the Society	1,444	14	0
Total Rs. ..	2,199	15	6	Total Rs. ..	2,199	15	6

The Society's accounts have been audited by Dr. J. A. Muliyil, Biological Control Research Officer at the Imperial Agricultural Research Institute, New Delhi, who was appointed for the purpose by the Executive Council. His remarks on the funds and accounts of the Society are as follows :—

> "I do hereby certify that I have examined the cash book, members' subscription book, savings bank book of the Imperial Bank of India and all vouchers pertaining to the various items of expenditure incurred during the course of the year, at New Delhi as well as at Lyallpur and Coimbatore. I am satisfied that the accounts have been maintained in order and all items of receipt have been credited to their proper heads. The balance to the credit of the Society is Rs. 1,444-14-0, of which Rs. 1,416-11-6 is in the Imperial Bank of India (New Delhi Branch) in the name of the Society and the rest is with the General Secretary and Treasurer, as floating advance for contingencies. I am indebted to the General Secretary for giving me all assistance in the auditing of these accounts."

Early in the year, a circular letter was sent round to the various universities in India, requesting financial help for the *Indian Journal of Entomology*, chiefly on the ground that the Journal, by publishing papers on general aspects of entomology, was bound to contribute to the advancement of the Zoological Science, the study of which the universities were so much interested to foster. It is a pleasure to announce that the University of the Punjab has donated a sum of Rs. 100/- per annum and I take this opportunity on behalf of the Society, to thank the University for its generosity.

The Society has now completed three years of its existence. It is to be hoped that members will help it enthusiastically to establish itself more and more firmly. Before I close I wish to acknowledge the help I received in carrying on the work of the Society from my colleagues, Dr. Taskhir Ahmad and Mr. M. S. Mani, while the constant advice and encouragement of Dr. Hem Singh Pruthi, Vice-President was invaluable.

Dr. Hem Singh Pruthi, on behalf of the President, briefly reviewed the progress of the Society, specially in relation to the publication of the *Indian Journal of Entomology*.

The house then discussed some modifications in the Rules of the Society as proposed by some of the Branch Societies and by the General Secretary.

On the question of electing "Fellows", the house accepted Dr. T. V. Ramakrishna Ayyar's proposal, recommeding that the rule relating to 'Fellows' be held in abeyance till the next annual general meeting in 1941.

The house resolved that the term of the Editorial Board be reduced to three years and this decision should take effect from the 1st January, 1940. At the end of three years, the retiring Board should elect one of its members to be a member of the new Editorial Board, the remaining members of which should be elected by ballot at an annual general meeting, as before. Members of the old Editorial Board should be eligible for re-election, and the Board will elect one of its members as the Chief Editor, as before.

In view of the increasing cost of production of the *Indian Journal of Entomology* and having regard to what other scientific societies in India are charging as subscription from their members, the house decided to increase the annual subscription payable by Ordinary Members, to Rs. 12/8/.-

Other modifications accepted by the house were the following :—

Voting for the election of office bearers should be by ballot, the ballot papers being sent in by post or presented personally.

Associate Members should receive a reprint of the part of the *Indian Journal of Entomology* containing 'Short Notes and Exhibits', 'Recent Research', 'Proceedings of Meetings', etc.

The General Secretary and the Joint Secretary should be elected from the headquarters of the Society and the latter should be the Treasurer.

On page 1 of the Rules, under "Election of members", 3rd line, delete "personally" ; on page 3, 2nd para, 1st line, delete "registered". Under "Executive Council" after the sentence "The Secretary shall be responsible..... Society" add "He shall also act as the Managing Editor of the publications of the Society" and delete this sentence from the next para ; and under "Executive Council", last para, substitute "November" for "October". On page 4, first para, instead of "Five" add "Fifty per cent of the" ; under "Annual General Meeting", 2nd line, substitute "weeks" for "months", 3rd line for "at least one month before the meeting" substitute "by the end of November".

The house unanimously agreed that the funds of the Society should be in a recognised bank, approved by the Executive Council and held jointly in the names of the Chief Editor and the Treasurer, on behalf of the Society. At the Annual General Meeting of the Executive Council the Chief Editor or the Managing Editor shall present an estimate of the cost of production of the Journal during the ensuing year for sanction by the Council. At the same meeting the General Secretary shall present an estimate of expenses likely to be incurred during the year, on behalf of the Society, apart from those connected with the Journal, for sanction by the Council. Any further expenditure found necessary during the year shall be incurred only with the permission of the President.

The house authorised the President and the General Secretary to revise the rules embodying the above modifications.

Dr. Hem Singh Pruthi, was elected President of the Society for 1940. Mr. Afzal Husain was elected as one of the Vice-Presidents from among the past Presidents of the Society. In consequence of Dr. Pruthi's election to presidentship, Dr. N. C. Chatterjee, Dehra Dun, was elected Vice-President of the Society and Mr. P. M. Glover, Namkum, Ranchi, a member of the Executive Council.

On a recommendation of the Executive Council, Sir A. K. Guy Marshall, Director, Imperial Institute of Entomology, London, was unanimously elected an Honorary Member of the Society.

The house sanctioned Rs. 30/-, as remuneration for clerical work during 1940.

Dr. T. V. Ramakrishna Ayyar proposed a vote of thanks to the out-going President, Mr. M. Afzal Husain, for his keen interest in and valuable services rendered to the Society from its very inception. He also thanked Dr. Hem Singh Pruthi and Dr. K. B. Lal for shouldering the major part of the Society's work and carrying it on so successfully through the year.

In the meeting on January 4, Dr. Hem Singh Pruthi read Mr. Afzal Husain's presidential address on "Uvarov's theory of phases in locusts".

BRANCH SOCIETIES (Up to May, 1940.)

DELHI BRANCH—NEW DELHI

29th February

General

Dr. J. A. Muliyil, Biological Control Research Officer, Imperial Agricultural Research Institute, New Delhi, was elected President of the Branch Society for 1940.

A resolution recording the members' sense of sorrow and loss to entomology on the death of Rai Bahadur C. S. Misra, Retired Assistant Entomologist at the Imperial Agricultural Institute, was passed.

A vote of thanks to the out-going President, Dr. Taskhir Ahmad, proposed by Dr. K. B. Lal, was passed unanimously.

12th March

Exhibit

Algal growth on wings of the desert locust—*Y. R. Rao*

Communication

(1) Biology of *Ocinara varians* and its parasites—*J. A. Muliyil*

(2) Egg-deposition by moths after death in cynide killing-tube—*Shumsher Singh*

18th April

Excursion and collection trip to Okhla, a suburb of Delhi. An enjoyable evening was spent in collecting specimens, specially those of aquatic insects.

THE BENGAL BRANCH—CALCUTTA

15th February

General — Mr. D. D. Mukerji of the Calcutta University was re-elected President of the Branch Society for 1940.

Communication — The determination of the rate of mortality of silk-worm in Bengal—*D. P. Raichoudhury* and *D. C. Sircar*

29th March

Communication — The life-history of *Termes redemanni*—*D. D. Mukerji* and *S. N. Raichoudhury*

Exhibit — Various stages of *Termes redemanni* and specimens of some termitophilous species.

10th April

Communication — Study and work on entomolgy in Bengal—*C. C. Ghosh*

THE PUNJAB BRANCH—LYALLPUR

18th November

Communication — The mango Mealy-bug *Drosicha stebbengi*—*A. Lateef*

21st December

Communication — Importance of birds in dissemination of San Jose Scale—*Asa Nand*

Exhibit — *Bryobia* sp. from chrysanthemum—*A. N. Sapra*

31st January

Discussion — On a paper entitled "Biological control of *Plutella maculipennis* Curt. in England" by J. Eliot Hardy—*K. N. Trehan*

28th February

Communication — Termites—*Ujagar Singh*

Exhibit — *Stathmopoda trissorrhiza* Meyr. from *analb* (*Zizyphus*) berries—*Gurcharan Singh*

30th March

Communication — Clean-up operations against the spotted bollworms of cotton—*Ganda Ram*

Exhibits — *Phytomyza atricornis*—adults and pupæ from ornamental plants. *Alphitobius lævigatus* F. from a kitchen—*K. N. Trehan*

SOUTH INDIA BRANCH—COIMBATORE

6th December

Communications — On the life-history and habits of *Oncocephale tuberculata*, Cliv., (Chrysomelidæ)—M. C. Cherian. Observations on *Pterodela* sp. nov., (Psocidæ)—*P. N. Krishna Ayyar.*

Exhibits — *Shirakia yokohamensis*, a parasite on *Scirpophaga* caterpillar; *Tetrastichus* sp., a parasite on *Plutella* caterpillar —*M. C. Cherian.* Teak galls caused by Cynipids; Cerambycid beetle, *Oberia* sp., boring into *Coleus* stem; *Eupterote canarensis*, on yam; *Xylotrepus gideon* (female ?); *Glyphodes* sp. defoliating dalbergia; *Apanteles* cocoons on *Chloridea* caterpillar—*T. V. R. Ayyar.*

20th May

General — Sri M. C. Cherian was re-elected President of the Branch for 1940.

Sri P. N. Krishna Ayyar gave a short account of the Annual General Meeting of the Entomological Society, held at Madras early in January, 1940.

Communications — On *Selepa docilis*, a minor pest on brinjals and its parasite *Euplectrus euplexiæ*—*M. C. Cherian.*

Exhibits — *Phæospilodes bambusae ?*, a Trypetid fly breeding on the tender shoots of bamboo; *Eutettix phycitis* Dist., a Jassid, a vector for the little-leaf disease of brinjal; *Amorphoidea arcuata* Marshal., a weevil breeding in tender cotton bolls—*M. C. Cherian. Toxorrhynchites immisericors* (Walk.), the elephant mosquito, breeding in cattle urine; *Estigene pardalis* Walk., a Lasiocampid moth simulating a dried leaf when at rest; *Ricania fenestrata*, a Fulgorid on jasmine—*T. V. Subramaniam. Telenomus* sp. (Probably *roheri*), an egg parasite of *Scirpophaga*—*P. S. Narayanaswami.*

The
Indian Journal of Entomology

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THE BIONOMICS OF *EMPOASCA DEVASTANS* DISTANT ON SOME VARIETIES OF COTTON IN THE PUNJAB

By M. AFZAL HUSAIN, M.A. (CANTAB.), I.A.S.,
Vice-Chancellor, University of the Punjab, Lahore
and
K. B. LAL, M.SC. (ALLD.), PH.D. (EDIN.),
Imperial Agricultural Research Institute, New Delhi

CONTENTS

INTRODUCTORY

The genus *Empoasca* Walsh (Eupterygidæ, Jassoidea) is well distributed throughout the world and contains over a hundred species of which about a score are injurious to various crops, *e.g.*, *E. flavescens* Fabr. to tea in north-east India, and sugarbeet in parts of central and southern Europe, *E. fabae* Harris to potato, beans and brinjal in eastern and southern U.S.A., *E. minuenda* Ball to avocadao in Florida. Over a dozen species infest cotton and about half of them are known to cause serious damage to this crop. The species of *Empoasca* infesting cotton in various parts of the world are listed in table I.

In India about two dozen species of *Empoasca* are known and of them *E. devastans* Dist. is economically by far the most important. This

species came into prominence over twenty-five years ago when it was found attacking the American varieties of cotton then newly introduced in the Punjab. Later, the failure of 3F cotton in the same province in 1913-14 was attributed mainly to jassid attack and it was obvious that *E. devastans* was the species involved. Since then several more outbreaks of this pest of a serious nature have occurred and the need for a thorough knowledge of the bionomics of this species has become more urgent than ever.

TABLE I. *Species of* Empoasca *infesting cotton plant*

Species	Locality	Economic status
E. doliche Paoli	Transvaal,	Not injurious
	Belgian Congo	,, ,,
E. distinguenda Paoli	Transvaal,	,, ,,
	Belgian Congo	,, ,,
E. benedettoi Paoli	Italian Somaliland	Injurious
	Anglo-Egyptian Sudan	Not injurious
	Tanganyka	,, ,,
E. facialis Jac.	Italian Somaliland	Injurious
	Tanganyka	,,
	Nigeria	,,
	Belgian Congo	,,
	Transvaal	,,
	Rhodesia	Very injurious
	Anglo-Egyptian Sudan	Injurious
E. decepiens Paoli	Egypt	Not injurious
E. flavescens Fabr.	Philippines	Injurious
E. gossypii Paoli	Haiti	,,
E. bigutulla Mats.	China and Formosa	,,
E. fabæ Harris	South Carolina	,,
E. terra-reginæ Paoli	Queensland	,,
E. notata Melichar	Bihar	Not injurious
E. formosana Paoli	Madras	,, ,,
E. devastans Dist.	Punjab	Very injurious
	N. W. F. P.	Not injurious
	Sind	Very injurious
	Bombay	Not injurious
	Madras	Very injurious
	Mysore	Not injurious
	Hyderabad-Deccan	,, ,,
	Central Provinces	,, ,,
	United Provinces	,, ,,
	Bihar	,, ,,
	Delhi	,, ,,
E. punjabensis Pruthi	Punjab	,, ,,
E. kerri var. *moti* Pruthi	Sind	,, ,,
Empoasca sp.	Fiji	Injurious
Empoasca sp.	Papua	,,

Information in literature on *E. devastans* is extremely meagre and apart from the original description by Distant, is confined to three contributions, namely, a report by George (1933) of a suspected sound producing organ in this species, a note by Lal (1937), dealing chiefly with the

behaviour of this species on hairy and non-hairy varieties of cotton, and a short account of its life history in south India by Cherian and Kyalasam (1938). Work on *E. devastans*, however, has been in progress in Madras (Madras Agricultural Station Reports, 1933-36), and in the Punjab since 1933 (an account of the latter was given by the senior author in the First Conference of Scientific Research Workers on Cotton in India, held in Bombay in 1937). The present paper deals mainly with the behaviour of *E. devastans* in relation to different varieties of cotton in the Punjab and some possible factors that may affect this behaviour. The work was carried out at Lyallpur for two years during 1935-37, when the junior author was a research student of the Indian Central Cotton Committee and the senior author, Entomologist to the government of the Punjab. Some observations were also made at Delhi and the paper has been finally prepared and written up at the Imperial Agricultural Research Institute, New Delhi.

Host Plants and Life History

At Lyallpur, in addition to cotton, *E. devastans* was found to live and breed on hollyhock (*Althæa rosea*), castor plant (*Ricinus communis*), brinjal (*Solanum melongena*), potato (*S. tuberosum*), *bhindi* (*Hibiscus esculentus*) and *ban kapas* (*H. vitifolius*). The last two plants are very favourite hosts. Recently it was observed breeding on *H. cannabinus* and also on some Cucurbit plants, at Delhi. Cherian and Kyalasam (1938) have recorded sunflower as one of the hosts of *E. devastans* in the Madras area, but although this plant is very common all over north India we have not noticed any stage of this jassid on it. Incidentally it may be pointed out that merely the presence of adult jassids on a plant is not an indication that the plant is one of its hosts unless the immature stages of the insect are also found on it.

The life history of *E. devastans* in the Punjab is as follows :—

Eggs are laid inside the leaf veins usually in the spongy parenchymatous layer between the vascular bundles and the epidermis and have an incubation period of about four to eleven days. The maximum number of eggs laid by a female, as shown by over two dozen observations, was twenty-nine but generally the female in captivity laid only half this number spread over a week.* The nymphs moult five times and their life-period varied from seven days in autumn to twenty-one days in winter. In the Bombay presidency, nymphs of *Idiocerus atkinsoni* Leth., *I. niveosparsus* Leth. and *I. clypealis* Leth. were observed by Wagle (1934) to undergo only four moults and to take eleven to thirteen days to reach the adult stage.

*Observation made by Dr. M. L. Bhatia, formerly research student of the Indian Central Cotton Committee.

Unmated adults of *E. devastans* lived for three months or longer but those that had paired did not survive beyond five weeks in summer and seven in winter. Mating generally took place either in the early morning or late in the evening and the insects were observed in this condition for over seven minutes at times. During copulation the two insects are attached together end to end, their heads pointing in opposite directions.

At Lyallpur this species breeds practically throughout the year with possible cessation for about two months from the last week of January. The early spring eggs are laid on hollyhock, brinjal, potato and from these the infection spreads to ratoon cotton and *bhindi*. Towards the end of June cotton seedlings are attacked and from this time onwards *bhindi* and American cottons are heavily infested. About the beginning of November the jassid population on cotton and *bhindi* and a little later, on *ban kapas* also, declines but the insect begins to appear on potato, hollyhock and brinjal again and it is on these plants that it passes most of the winter. Altogether eleven generations were observed in a year but as the adults are comparatively long-lived and oviposition proceeds at a slow rate there is considerable over-lapping of broods and in the following table the duration of the various generations is only very approximate :—

TABLE II

Generation	Duration	Days
I	1st. week April to 1st. week May	30
II	1st. week May to 1st. week June	30
III	2nd. week June to 2nd. week July	30
IV	2nd. week July to 1st. week August	24
V	2nd. week August to 1st. week September	18
VI	1st. week September to 3rd. week September	15
VII	3rd. week September to 1st. week October	15
VIII	1st. week October to 3rd. week October	15
IX	3rd. week October to 1st. week November	18
X	1st. week November to 2nd. week December	32
XI	2nd. week December to 3rd. week January	46

Description of various stages

Egg (Pl. IV, fig. 1).—Length 0·73 mm., breadth 0·24 mm. Translucent with a yellowish tinge when freshly laid, later turning greenish yellow. Elongated, slightly hooked towards the anterior end, the other end being broadly pointed. When about to hatch, a pair of brownish red eyes shine through the chorion near the anterior end.

First instar nymph (Pl. IV, fig. 2).—Length 0·6 mm. Transparent and yellowish when newly hatched, later greenish yellow. Eyes conspicuous, reddish brown and oval. Head with six dorsal spines along anterior margin, and a triangular area between eyes (apex pointing towards prothorax). Thoracic segments distinct, prothorax narrow in middle, posterior or lateral angles of meso- and meta-thorax each with a spine, the hind pair of legs slightly longer than the two anterior pairs. Abdomen apparently nine-segmented, first almost as broad as thorax, second with lateral conical projections distinctly broader than the other segments,

third to eighth with long prominent lateral spines, each with a transverse row of four dorsal spines, knobbed at extremities, ninth segment narrowest and only slightly longer than the eighth.

Second instar nymph (Pl. IV, fig. 3).—Length 1·03 mm. Differs from the first instar nymph in having eyes white superficially, dark-reddish underneath, in the proboscis reaching the third abdominal segment, a transverse greyish brown patch near posterior margin, rudimentary wing pads along posterior ends of sides of meso- and meta-thorax, hind tibiae with two single rows of spines, second abdominal segment with rounded projections at sides and with two minute spines on dorsal surface, dorsal row of spines on segments three to eight with two very minute spines at sides, abdomen broadest at third segment, ninth segment longer and narrower than others, with a ring of spines along posterior margin and a pair on dorsum.

Third instar nymph (Pl. IV, fig. 4).—Length of male 1·23 mm., of female 1·33 mm. Yellowish green. Differs form the second instar nymph in having wing pads more prominent, each with a small spine on tip and indistinct greyish brown patches across posterior margins of meso- and meta-thorax, abdomen broadest at fourth segment.

Fourth instar nymph (Pl. IV, fig. 5).—Length of male 1·50 mm., of female 1·69 mm. Head and thorax greenish yellow, abdomen bluish green, eyes greyish purple. Differs from the third instar nymph in having proboscis reaching first abdominal segment, each thoracic segment with a pair of spines on dorsum, wing pads reaching fourth abdominal segment, four dark greyish round spots at posterior margin of meso-thorax and two at posterior margin of meta-thorax, a rudimentary tenth segment at the end of abdomen.

Fifth instar nymph (Pl. IV, fig. 6).—Length of male 2·18 mm., of female 2·28 mm. Greenish yellow with legs and abdomen bluish. Spines at anterior margin of head very minute, proboscis just reaching coxae of third pair of legs, prothorax with anterior margin convex, posterior concave, meso-thorax longest, wing pads reaching fourth or fifth abdominal segment, spines at tips of wing pads much reduced, greyish brown marks on the meso- and meta-thorax, as in the fourth instar, four greenish brown spines transversely arranged at posterior margins of segments three to eight. Rudiments of tenth segment become visible in the form of an anal tube.

Adult (Pl. IV, fig. 7).—A description of the adult insect is given by Distant (1918) based on specimens collected at Nagpur. The most noteworthy feature by which the adults can be recognised in the field is the presence of a prominent black spot on each of the tegmina near apex of claval area. Like many other insects, the adults of *E. devastans* are subject to seasonal changes of colouration. The common summer form is a yellowish green insect with antennæ pale white, eyes a mosaic of green and white, tegmina with greenish tinge and legs pale green. The winter form is reddish brown, with the antennæ pale white, eyes dark violet, tegmina with a brownish tinge and legs green. In between these two forms, there may be many intermediate forms depending upon the time of the season.

Habits

The nymphs of the first and second instars prefer to feed near the bases of the leaf veins. During the later instars they get distributed all over leaf but feed chiefly on the under-surface. Ordinarily they do not move about much but become very active when disturbed. Nymphs of the last two instars are able to jump a distance of about eight inches at times of danger or provocation. Cherian and Kylasam (1938) observe that the older nymphs develop a tendency to become gregarious and crowd on the underside of the semi-dry basal leaves. Of this habit we have had no marked evidence.

Usually cotton in the pre-flowering stage is most susceptible to attack and in the Punjab this period coincides when the plant is eight to ten weeks old. According to Sloan (1938), *E. terra-reginæ* Paoli is most abundant on cotton in Queensland when the crop matures. In South Africa the susceptibility of the plant is said to increase as it matures and the earliest bolls get time to ripen before attack by *E. facialis* Jac. has reached its worst. But if the early bolls have already been damaged through bollworm or other attack and further setting also of the bolls is prevented by jassid attack, there is little return from the crop (Parnell 1923-25).

NATURE AND SYMPTOMS OF INJURY

Jassids, like other sucking insects, cause injury to their hosts by sucking and desapping the plant. This injury is probably insignificant as compared to the damage which they cause by injecting some toxic saliva into the plant tissues, which are killed in the process, resulting in the browning, crumpling and withering of the leaf and its subsequent death. Peat (1928) observed that damage caused by jassids to cotton in South Rhodesia occurred through the injection of a toxic secretion rather than by the transmission of a disease organism. Paoli (1930) attributed the leaf curling of cotton in Italian Somaliland to the effect of the saliva of *E. facialis* Jac. and not to the transmission of a virus capable of development after inoculation. Sloan(1938) has stated that jassid injury to cotton in Queensland is due to the injection of toxic juices by *E. terra-reginæ* Paoli. In the case of *E. devastans* observations showed that the numbers of adults and nymphs present on a plant often did not appear to be enough to cause all the injury, by simple feeding alone, which the plant had sustained. There is very strong suspicion, therefore, that this species also injects some kind of toxin into the plant tissues in the act of feeding.

It is of interest to note that while cotton jassids, both in the Punjab and in South Africa, have long been under suspicion for transmitting a virus disease, often known as the leaf curl or crinkle of cotton, there is no evidence to suggest that *E. devastans* acts as a vector of any virus disease in India. Indeed, so far as cotton is concerned, a virus disease of this plant has not yet been definitely established and Afzal's (1936) suspicion of a virus disease of cotton in the Punjab, similar to 'stenosis' or 'smalling' disease in the U.S.A., has remained unconfirmed.

As will appear presently, the hosts of *E. devastans* can be grouped into two categories with respect to the infestation of this insect on them : resistant and susceptible. There is some indication that at the commencement of attack by *E. devastans* two slightly differing types of symptoms are produced on the two types of its host plants. On resistant varieties, the attack starts with a wilting of the leaf followed by the drying up of

the apex and periphery which become brown and necrotic. On susceptible varieties, there is a general mottling, accompanied by a curling of the entire lamina and later, appearance of brown necrotic patches which extend to the entire area. Ultimately in both, the leaf becomes a dull brick red colour, relieved only by very narrow strips of yellowish green along the principal veins. This condition is apt to be confused (see Jenkins, 1936) with the reddening of cotton leaves said to be a feature of the failures of the cotton crops in the Punjab and perhaps also in Sind. The two symptoms are, however, distinct. The leaves affected by jassids are a dull brick red colour, while those associated with failures of cotton crops, which have nothing to do with cotton jassids, are deep crimson red in colour.

Behaviour on Different Varieties of Cotton

E. devastans exhibits considerable discrimination in its attack on different varieties of cotton. In the Punjab as a rule the *desi* cottons are more or less immune while the American cottons are in general susceptible, although certain varieties, such as, 4F and *L.S.S.* are less susceptible than certain others such as 38F, 289F and 43F. The insect however, is not necessarily consistent in its attack upon a variety. It may attack the same variety in one place but not in another. For example 43F was observed to be heavily infested in Lyallpur but not in Sargodha district during the same season (1936). It is also interesting to note that the South African variety U4 which is immune from the attack of *E. facialis* in its native habitat becomes susceptible to *E. devastans* when grown in the Punjab and Madras.

The differential behaviour of *E. devastans* in respect of its hosts is directly connected with the question of their resistance to its attack. This resistance may be the result of either or both of the following two operations on the part of the insect : (*i*) inability of the females to oviposit on a host (*ii*) inability of the nymphs to feed and flourish on it. In the case of cotton varieties it was considered important to determine, first, which of these causes was operating or whether both were equally responsible for keeping a variety free from jassid attack, and, secondly, to discover the factors in the cotton plant itself which helped to produce this result.

In table III results are given of experiments carried out to test the capacity of development of *E. devastans* nymphs on six varieties of cotton, namely, *Jubilee*, *Mollisoni* 15, *Mollisoni* 39, *Rosae* 10, 45F and 4F. Equal numbers of first instar nymphs were caged on plants of each of these varieties and those successfully completing their life cycles and becoming adults were noted.

Table III. *Development of adults from 50 nymphs caged on six varieties of cotton plants, 41-45 days old, in 1936*

Variety	Total No. of adults emerged	Percentage of success	Max. duration of nymphal life	Range of emergence (days)	Date (1936)
Jubilee	39	78	16	11	1.X—16.X
M. 15	40	80	16	10	1.X—16.X
M. 39	40	80	16	8	1.X—16.X
B. 10	40	80	15	7	1.X—15.X
4F	39	78	13	8	1.X—13.X
45F	40	80	13	8	1.X—13.X

Development of adults from 80 nymphs caged on six varieties of cotton plants 61-65 days old

Jubilee	79	98.7	21	15	20.X—10.XI
M. 15	65	81.2	18	13	20.X— 7.XI
M. 39	76	95.0	20	13	20.X— 9.XI
B. 10	62	75.5	21	16	20.X—10.XI
4F	65	81.2	18	11	20.X— 7.XI
45F	75	93.7	18	11	20.X— 7.XI

In another set of experiments the comparative numbers of eggs laid on American and *desi* varieties by equal numbers of females were determined (Table IV). Plants of *Mollisoni* 39 were used against 45F and 38F respectively as controls. All the plants were of the same age and offered approximately equal leaf area. As direct counting of the eggs was impossible without injuring the plants, the number of nymphs hatching was taken as indication of the numbers of eggs laid.

Table IV

Variety	Age of plants (days)	No. of adults put on	No. of nymphs hatched	Duration of experiment
*Moll.*39	52	60♂60♀	12	3.VIII—27.VIII
*Moll.*39	,,	,,	7	4.VIII—27.VIII
45F	59	,,	46	4.VII—29.VII
*Moll.*39	52	,,	8	2.VIII—18.VIII
*Moll.*39	,,	,,	3	3.VIII—18.VIII
*Moll.*39	,,	,,	8	4.VIII—18.VIII
45F	54	,,	117	4.VIII—18.VIII
*Moll.*39	56	15♂25♀	31	17.X— 2.XI
*Moll.*39	,,	,,	29	17.X—31.X
*Moll.*39	,,	,,	26	17.X— 1.XI
38F	,,	,,	86	17.X— 5.XI
38F	,,	,,	156	17.X— 5.XI

It was considered possible that although nymphs could develop equally well on immune and susceptible varieties yet the resulting imago might suffer from sterility. It was, however, found that adults reared on *Indicum* 50 (a resistant variety) and on *Hibiscus esculentus* (a favourite host) and caged on 45F (a susceptible variety) for egg-laying bred equally successfully (Table V).

TABLE V. *Eggs laid on 45F by adults reared on different plants*

Adults reared on	No. of adults caged for egg-laying	No. of nymphs hatched	Date and duration of experiment
Indicum 50	13♂ 9♀	141	28.VIII-24.IX, 27 days
H. esculentus	,,	60	28.VIII-24.IX, 27 days

The following conclusions can be drawn from the results of the experiments described above :—

1. The nymphs of all stages of *E. devastans* have no difficulty in feeding and developing on different varieties of cotton, susceptible or resistant, hairy or non-hairy.
2. There is marked reduction in egg-laying (or possibly hatching of nymphs) on resistant varieties.
3. Nymphs reared on resistant varieties develop into fertile adults just as well as those reared on susceptible varieties.

The factors likely to be responsible for producing immunity in the cotton plant from the attack of *E. devastans* were studied (*i*) by noting the incidence of the insect on the plants, (*ii*) by comparing the pH values of the juice of leaves from different varieties and (*iii*) by determining the hairiness of leaves of susceptible and resistant varieties. The methods and results are detailed below :—

(*i*) Observations were made regularly, throughout the cotton season, to assess the comparative incidence of jassid population on—

(a) Plots of 38F and 45F cottons sown on five different dates from 15. IV to 1.VII at intervals of a fortnight or more.

(b) Plots of 43F receiving six different manurial treatments and a control plot.

(c) Plots of 4F receiving nine different types of irrigation.

The results showed that, other conditions being equal, early sown cotton is less liable to attack by jassids than late sown cotton and the

period of maximum infestation usually occurs about the time immediately preceding bud formation. Different manurial and irrigation treatments, however, did not make any apparent difference in the incidence of the jassid. The data, on which these findings are mainly, but not exclusively, based, are presented in the tables VI, VII and VIII.

TABLE VI. *Number of* E. devastans *nymphs counted on representative plants of 38F cottons sown on different dates in* 1935

38F sown on	2. VIII	10. VIII	19. VIII	28. VIII	9. IX	18. IX	27. IX	8. X	Total
15. IV	75	61	59	28	8	14	9	15	269
5. V	72	51	68	40	16	20	8	15	290
20. V	134	62	83	48	10	27	18	18	400
5. VI	205	91	100	92	36	17	23	13	577
1. VII	25	157	106	186	98	113	29	38	752
43F sown on									
15. IV	35	13	33	11	10	11	4	23	140
5. V	49	23	28	10	16	8	18	25	177
20. V	47	34	40	46	19	23	12	12	233
5. VI	120	48	39	50	12	19	25	21	334
1. VII	5	105	63	97	36	19	26	23	374

TABLE VII. *Number of* E. devastans *nymphs counted on representative plants in plots receiving different manurial treatments* (1935)

Manurial treatment	30. VII	10. VIII	20. VIII	30. VIII	10. IX	21. IX	Total
Compound artificial manure, 1 md. per acre on I. VII.	6	9	3	23	18	2	61
Super phosphate, 1 md. per acre on 1. VII	7	19	15	15	10	5	71
Soda nitrate, 100 lbs. per acre on 15. IX	10	15	10	14	37	10	96
Soda nitrate 100 lbs. per acre on 30. VIII	7	19	16	12	61	9	124
Amm. sulphate, 1 md. per acre on 15. IX	12	12	12	33	41	2	112
Amm. sulphate, 1 md. per acre on 30. VIII	6	9	14	11	13	5	58
Control	4	25	15	10	39	3	98

TABLE VIII. *Number of* E. devastans *nymphs counted on representative plants in plots receiving different water treatments* (1935)

Water treatment	25 VII	5. VIII	13. VIII	26. VIII	4. IX	13. IX	25. IX	Total.
1st. water 3 wks. after sowing, subsequent waterings at 4 wks. interval.	2	37	10	13	24	9	13	108
1st. water 4 wks. after sowing, subsequent waterings at 4 wks. interval.	9	61	29	30	50	12	6	197
1st. water 5 wks. after sowing, then at 5 wks. interval.	7	7	12	41	13	6	11	97
1st. water 3 wks. after sowing, then as the zamindar* watered his crop.	14	29	27	19	17	6	8	120
1st. water 3 wks. after sowing, then at 2 wks. interval.	20	54	16	26	16	10	8	150
1st. water with zamindar* and two late waterings.	5	29	27	29	38	41	12	181
Standard zamindar* control.	6	21	23	33	37	29	11	160
Watering according to zamindar* up to 15 IX and then stopped altogether.	2	22	30	18	20	10	9	111
1st. watering 6 wks. after sowing, then at 4 wks. interval.	9	12	15	56	9	17	1	112

(*ii*) The pH value of the juice of leaves of the plants given in table IX was determined early in September. No correlation was noticed between the acidity of leaf juice and susceptibility to jassid attack.

(*iii*) An examination of the density and length of hairs on leaves of seven varieties of *desi* and American cottons was made with a view to determining the correlation, if any, between this character and jassid resistance. A note on this part of the work has already been published by one of us (Lal, 1937) and the conclusion was drawn that varieties having either very long hairs or a high density of them or having a

* Zamindar means the ordinary farmer of the Punjab. He has his own scheme of irrigating his crops based on experience and 'Standard Zamindar control' implies that watering was given according as he watered his cotton crop.

TABLE IX

Plant	pH value	Susceptibility to jassid attack
38F	6.34	very susceptible
45F	6.38	very susceptible
Hibiscus esculentus	6.46	very susceptible
43F	7.28	susceptible
Solanum melongina	5.54	susceptible
Labh Singh selection	6.10	not susceptible
Mollisoni	5.64	not susceptible

combination of both these characters are not necessarily resistant to jassid attack. It appears that while practically all jassid-resistant varieties of cotton are hairy (the *desi* cottons have all high hair density, though their hair lengths are short) all hairy varieties (*e.g.* 43F, 47F) are not necessarily resistant.

Views about the connection between hairiness of cotton leaves and their resistance to jassid attack have been very conflicting. Parnell (1928) considered that both the density and the length of hairs were concerned in making a variety susceptible or resistant. According to Sloan (1938), resistance apparently depends largely on the type and numerical density of the hairs but there is a much closer relationship between hair length and resistance than between the numerical density of the hairs and resistance. We are not inclined to place much reliance on hairiness, whether of density or of length, as a jassid-resistant character but it is possible that hairiness is sometimes apparently associated with chemical or other characters really concerned in jassid resistance and acts as a symptom of such resistance.

CONCLUSIONS

There are several interesting facts that emerge out of the present study. *E. devastans* breeds rapidly and has a fairly large number of generations in a year. Its powers of dispersal may not be very great but within a field it can be and often is very active. It can live and breed on a number of alternative host plants found throughout the year, but in cotton it shows distinct, though varying degrees of, preferences for certain varieties for egg-laying. Both nymphs and adults suck the juice of leaves and, in all probability, inject a toxic substance contained in the saliva into the plant tissues which cause characteristic symptoms on the leaves and ultimately their death. It is a noteworthy fact that no parasites of *E. devastans* have, so far, been recorded. These factors combine to make this Jassid all the more serious as a pest of cotton in India. Some of the best cotton

varieties, *e.g.*, 289F in the Punjab, have had to be given up because they could not withstand or avoid its attack. At times *bhindi* and brinjal also suffer heavily from its attack and these are important vegetables in many parts of India.

Various control measures have, therefore, been tried against *E. devastans* in the Punjab and Madras and against some allied species injuring cotton and other crops in Africa, Queensland, Fiji and several other countries. In the Punjab, the methods tried included catching of adults with a hand net, use of light traps, dusting with a mixture of calcium cyanide and wood ash (1 : 8) and spraying with rosin soap and with rosin compound. The method of sweeping was found to be very limited in application. Although *E. devastans* is positively photo tropic, light traps did not justify their use on a field scale. Dusting gave a kill of over 90%, but calcium cyanide is very expensive. Spraying was successful on a small scale. Cherian and Kylasam (1938) have reported that contact sprays with "nicotine" have given very good results against adults and nymphs, specially the latter, in the Madras presidency. The method of chemical control, however, of a pest of such an extensive crop as cotton, is full of practical difficulties. Judging by the absence of any recorded parasites of *E. devastans*—indeed information about the parasites of species of *Empoasca* seems remarkably meagre—and the practical ineffectiveness of its predator enemies (spiders, *Camponotus* ants, etc.) it seems that the biological method of control can do little to reduce the population of this Jassid.

A more promising line of approach has been to evolve jassid resistant varieties of cotton, and some success has been achieved in this work both in the Punjab and elsewhere. The work of breeding, however, has to be done by the cotton breeder but in doing it, if he is to avoid the method of hit or miss, as is the case at present, he must have a full knowledge of the characters which make a variety resistant to jassid attack. The work reported in this paper points to the conclusion that a variety is resistant because of the inability of the female jassids to oviposit on it and increase their progeny. Secondly, since the eggs are generally laid in the leaf veins, it is very probable that the resistant character resides in or is in some way associated with the leaf veins which should be carefully studied in future investigations. Thirdly, that too much reliance should not be placed on hairiness of leaves as a character of jassid resistance. And lastly, since there is a strong suspicion that the jassids in the course of feeding inject a toxic substance in the leaf tissues and thus cau e their death, the possibility of altering the plant sap by manuring, irrigation, etc., in a way that will in some way make the toxin ineffective as soon as it is injected in, should be explored. Future work along these lines may prove extremely useful in the control of cotton jassids.

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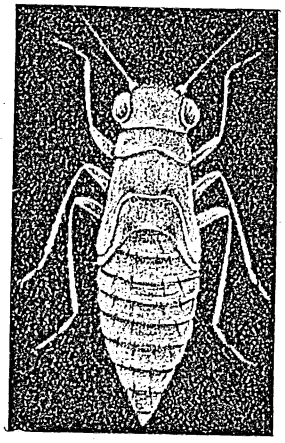
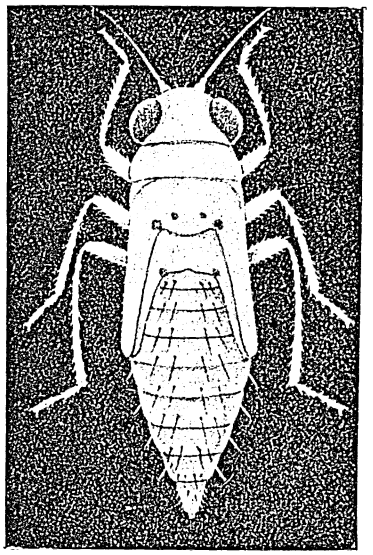
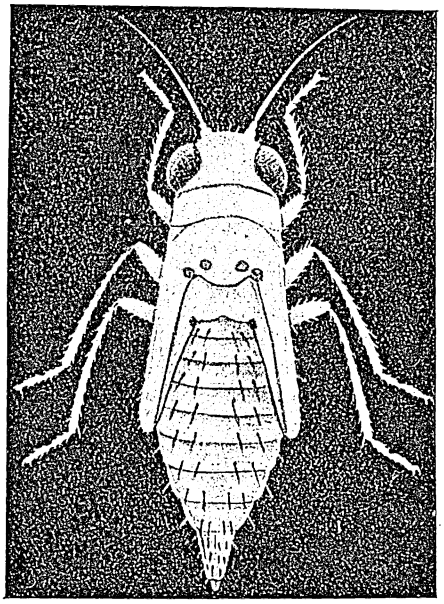
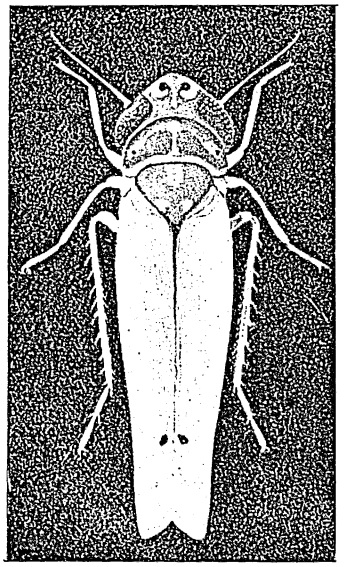


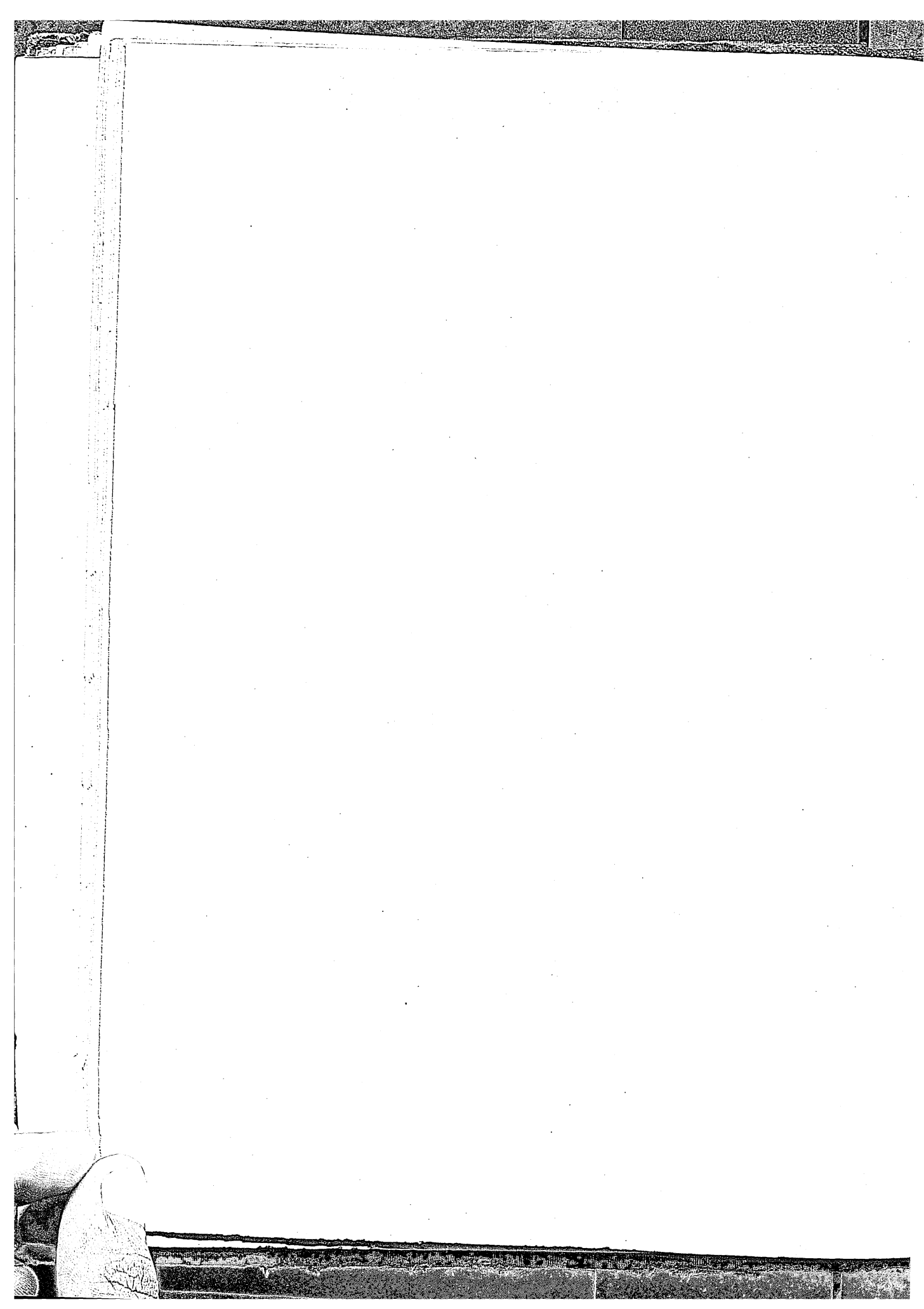






EMPOASCA DEVASTANS DISTANT

FIG. 1. Egg, (×23). FIG. 2. First instar nymph, (× 28). FIG. 3. Second instar nymph, (× 24). FIG. 4. Third instar nymph, (× 29). FIG. 5. Fourth instar nymph, (× 30). FIG. 6. Fifth instar nymph, (× 22). FIG. 7. Adult, (× 16).



PRELIMINARY NOTE ON SOME DIRECTIONAL CHANGES AMONG LOCUSTS AND OTHER ACRIDIDÆ, AND THE IMPORTANCE OF THE THIRD INSTAR*

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CONTENTS

I. INTRODUCTION

In the Acrididæ, as in other insects, there is, with each succeeding moult, generally a progressive change of various characters, such as the size of organs, the intensity of various physiological processes, etc., but the direction of the change usually remains constant from the first to the final instars. Some observations made on certain Acrididæ, however, show that a number of directional changes also take place.† These changes occur, in the Acrididæ, generally between the third and fourth instars. In some other respects also, the middle one or two instars differ from the rest. The changes described below have so far been shown to occur in a number of locusts. Some observations also refer to two grasshoppers, *Melanoplus differentialis* Thomas and *Chorthippus parallelus* Zett. The normal number of moults is five in the locusts discussed here, six in *Melanoplus differentialis* and four in *Chorthippus parallelus*.

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*A preliminary abstract of this paper appeared in *Proc. 25th Indian Sci. Congr.* (Calcutta), 1938, Pt. III, *Abstracts*, pp. 173-174. The present paper is a considerably altered version of the original. The term "reversal changes" employed originally has been changed to the term "directional changes", which seems more appropriate.

† The Acrididæ do not stand alone in this feature. It has been brought to my notice that white-flies (Homoptera, Aleurodidæ) also show directional changes. Here, the thoracic legs are relatively well developed in the active first instar larva, but undergo progressive reduction in the sedentary second, third and fourth instars; finally, they re-develop fully in the adult white-fly.

The directional changes here referred to must be clearly distinguished from either a slowing down or a quickening of growth. The essential feature of these changes is not a rise or fall of the growth-rate, but a complete change of direction—a kind of right-about-turning—of the relative position occupied by an organ or of a physiological process.

In this note I have brought together the hitherto scattered and insufficiently appreciated data in regard to such changes in some Acrididæ. An explanation of the phenomena concerned is also attempted.

I am indebted to Dr. Baini Prashad and Dr. H. S. Rao for kindly going through the manuscript and giving me the benefit of their criticism.

II. EXAMPLES OF CHANGES

(*a*) *Morphological Changes*

1. *Elytron- and wing-pads* (Fig. 1).—The elytron and wing-rudiments in the Acrididæ lie at first at the sides of the body and point downwards. At a certain later stage, this position is reversed and these rudiments are reflected on to the back of the hopper, turning on their bases as the fulcrum. They thus come to occupy a position on the back of the

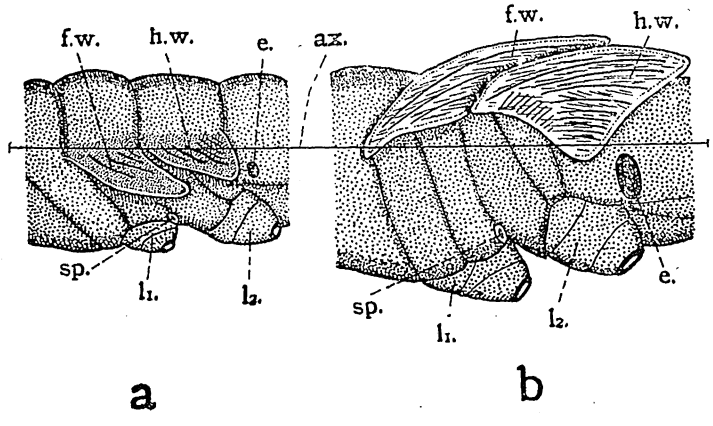

Fig. 1. Side views of thoracic portions of hoppers of *Schistocerca gregaria* Förskal, showing the elytron- and wing-pads. (*a*) Normal third stage, and (*b*) normal fourth stage hopper. Note the change of direction of the pads in the fourth stage.

ax., axis for directional change of elytron- and wing-pads ; *e.*, auditory apparatus ; *f.w.*, fore-wing ; *h.w.*, hind wing; l_1., l_2., bases of meso- and meta- thoracic legs respectively ; *sp.*, spiracle.

hopper such that the wing-rudiments partially cover the elytron-rudiments on the outside.* It is interesting to note that in all locusts for which data are available (*vide* Uvarov, 1928), this change of direction occurs at the moult between the third and fourth instars. These locusts are : *Schistocerca gregaria* Forsk. and *S. paranensis* Burm., *Locusta migratoria* L., *Dociostaurus maroccanus* Thnb., *Locustana pardalina* Wlk. and *Calliptamus italicus* L. In all of them there are normally five moults, except in the female of *Calliptamus italicus* which undergoes six moults without, however, any alteration in the morphological stage in which the change in the direction of the elytron- and wing-pads takes place.

2. *Growth coefficients of the body and of certain of its parts.*—Spett (1930 and 1932), while studying quantitatively the development of the secondary sex characters in *Chorthippus parallelus* Zett., measured certain of the body-parts such as the width of head and pronotum, and the length of pronotum, hind femur, antenna, elytron and wing. He also calculated their coefficients of variation—growth coefficients or Przibram's quotients —in various instars. His conclusions (1932, pp. 501-2) are : " The variation of *Chorthippus parallelus* in all stages is investigated separately. In order to settle the difference in the variation of the males and the females the material is insufficient. However, the coefficients of variation are interesting from another point of view. The table of the coefficients of variation shows that the variation is rather great in the first stage, towards the third it decreases considerably, in the fourth and in the adult insects it increases again." Thus, a directional change occurs in the fourth stage in the growth coefficients of certain parts of the body.

Bodenheimer (1927) showed that in *Schistocerca gregaria* Förskal the greatest amount of relative growth occurs during the third stage, the growth quotients for body-length $\left(\frac{\text{length in one instar}}{\text{length in previous instar}}\right)$ being as follows:—

Between instars	Growth quotient
I and II	1.57
II and III	1.27
III and IV	1.96
IV and V	1.56

*It has been pointed out to me that " the folding up of the wing-rudiments after the third moult is perhaps a physical adaptation of the insect to prevent damage to these organs while hopping. During the 4th and 5th stages, the rudiments reach a respectable size and would be more likely to be damaged during violent jumps if they happen to hang down." This is a possible *teleological* explanation of the phenomenon of the directional change in the position of the elytron- and wing-rudiments in relation to the body. It, however, does not answer the question as to why the elytron- and wing-rudiments do not have the upward position from the very first instar so as to obviate the need for any subsequent directional change. Nor does it throw any light on the mechanism by which the directional change is brought about at a particular stage of development of the insect.

This shows that the third stage is in some way exceptional, and the phenomenon would appear to be significant when considered with the fact that extra-moulting usually occurs in that stage, as is described hereafter.

(*b*) *Behaviouristic Changes*

In the first and second instars of *Locusta migratoria migratorioides* Reich. & Frm., if hoppers which are being reared under a wet atmosphere (relative humidity nearly 100%) are placed in a dry atmosphere (relative humidity 5-20%) during experimental determinations, the change has a depressing effect upon their locomotor activity. In the third and following instars, on the contrary, a similar change has a stimulating effect upon their locomotor activity (Key, 1936 B, p. 411). In other words, a directional change occurs between the second and third instars.

Again, Edney (1937), while studying the spontaneous locomotor activity in *Locusta migratoria migratorioides* Reich. & Frm. by the actograph method, found that the " activity figure "* of the hoppers (average of both the sexes) fell up to the third stage, but rose in the fourth stage, the rise being maintained in the fifth (Table I). On separate analysis of the sexes, this directional change in the third instar was found to apply to female nymphs only.

TABLE I. " Activity figures " of *Locusta migratoria migratorioides* Reich. & Frm. (From Edney.)

Instar	Activity figure		
	Male	Female	Average
II	42.4	54.1	48.2
III	50.4	28.3	39.3
IV	114.8	192.3	153.5
V	137.3	214.5	175.9

*The " activity figure " for each nymphal stage was calculated as follows:—The actograph record was divided into 10 sections and the average taken for each 10% division. The figures thus obtained were added for the whole stadium and the average again taken. This gave the average " activity figure " for each instar. (For fuller description, see Edney, 1937.)

(c) *Physiological Changes*

1. *Respiratory metabolism.*—Butler and Innes (1936, p.300) have shown in both the solitary and migratory phases of *Locusta migratoria migratorioides* Reich. & Frm. that "there is a marked falling off in the rate of oxygen uptake per square centimetre of body surface from the first instar to the third instar. From the fourth instar onwards to the adult stage an increase in the rate of oxygen uptake was recorded. This decrease and subsequent increase in the rate of oxygen uptake per unit area of body surface, throughout the life cycle, has not yet been explained." These authors thus observed a directional change in the intensity of metabolism between the third and fourth instars.

Bodenheimer and Reich (1929) stated that in *Schistocerca gregaria* Förskal, the respiratory intensity, *i. e.*, oxygen uptake per unit weight per unit time, diminishes progressively from the first to the fifth instars, and the surface-area law of Rubner (1883) is, therefore, obeyed. As remarked by Butler and Innes (1936), this statement is correct, as is evident from the data of Bodenheimer and Reich themselves, between the temperatures 14°-25°C. only. At temperatures between 29°C. and 44°C., the respiratory intensity increases in the third instar and then falls in the fifth (Table 22 of Bodenheimer and Reich), so that Rubner's law cannot be said to hold good. According to Butler and Innes (1936, p. 303) this deviation in the third instar of *Schistocerca* "appears to be similar to that obtained for *Locusta migratoria* in the third instar." Obviously, however, it is not so. Whereas in *Locusta* there is a falling off in the respiratory intensity from the first to the third instars and an increase subsequently, in *Schistocerca* the reverse apparently obtains between 29°C. and 44°C., *i.e.*, the respiratory intensity is higher in the third instar when compared to the first, and is lower in the fifth instar when compared to the third. Nevertheless, the interesting fact remains that a directional change in metabolic intensity occurs after the third stage in *Schistocerca*, although the direction of the change is opposite to that obtaining in *Locusta*.

2. *Extra-moulting.*—In the Madagascar race of the migratory locust, *Locusta migratoria capito* Sauss., Zolotarevsky (1933) showed that there are always six instars in the female, and usually six, but sometimes five, in the male. He further showed that the extra instar, leading to the 6-instar cycle, always represents an extra third instar, as is shown by the wing-pads which are lateral and point downwards. In *Locusta migratoria migratorioides* Reich. & Frm., on the other hand, the extra instar, which occurs only in females, sometimes represents the third and sometimes the fourth morphological stage, as determined by the position of the wing-pads (Key, 1936A).

In *Schistocerca gregaria* it has been found that the extra instar, which occurs in both sexes, most commonly represents the third morphological stage, and rarely the fourth. More rarely still, two extra moults may occur—in the second and fourth or in the third and fourth stages.

In *Locusta migratoria capito* and *Schistocerca gregaria*, therefore, the third instar is in some way intimately concerned with extra-moulting.

Hodge (1933) found that in *Melanoplus differentialis* one or even two extra moults may occur. This feature could not be correlated with diet which was varied in the experiments, other conditions remaining constant. Key (1936 A, p.83) found that in *Locusta migratoria migratorioides* Reich. and Frm., the extra moult, which resulted in the abnormal 6-instar cycle, " appeared in all the females hatching from two particular egg-batches, and appeared irrespectively of the humidity at which the hoppers had been kept. All the males from these two egg-batches had only five instars." Key concluded that the propensity to show a sixth or extra instar is an inherited one and is not conditioned by the external environment.

It should be pointed out that the difficult subject of extra-moulting is as yet far from being thoroughly understood, and the conclusions so far arrived at should be regarded as tentative.

Discussion and Conclusions

From the data described above, it will be seen that among locusts and some other Acrididæ, certain important changes—morphological, physiological and behaviouristic—take place when the hoppers pass from the third into the fourth instar, and, in one instance, from the second into the third. These are mostly directional changes and affect the direction of the position of the wing- and elytron-rudiments in relation to the body, the growth coefficients of certain parts of the body, the respiratory intensity and, finally, the locomotor activity. Extra-moulting, on the other hand, is an example of a non-directional change. Spett (1932, p.502) remarked that in *Chorthippus* " the falling of the variability towards the third stage can be explained most easily by a regulation of an automatic character . . . ". That the majority of the changes detailed above are brought about by an automatic regulation, seems very probable. The precise nature of the regulation, however, needs further elucidation.

In some examples of directional changes, like those concerning the wing- and elytron-rudiments, the automatic regulation, which must primarily be of a physiological nature, is, so far as is known, not influenced by the external environment. In other cases, on the contrary, it is so influenced, as is seen in the respiratory intensity of *Schistocerca gregaria* at high and low temperatures. Whether this applies also to changes in respiratory

intensity in *Locusta migratoria migratorioides* is not known, since data for low temperatures are not available for this insect. If, however, it does apply, it will be seen that temperatures higher than 25°C.—for *Locusta* the respiratory intensity at 27°C. only has so far been studied—affect this regulation in the opposite direction to that in *Schistocerca*. Key (1936A) has brought forward some evidence to show that the occurrence of extra-moulting calls for some genetical explanation, and from Hodge's (1933) work it would appear that this feature is evidently not connected with diet.

Briefly, therefore, the automatic regulation concerned is of three kinds : (1) Physiological regulation not primarily influenced, so far as is known, by the external environment. (2) Physiological regulation influenced by the external environment. (3) Genetical regulation not influenced, so far as is known, by the external environment.

It is probably significant that practically all the three kinds of regulations manifest themselves, as a rule, when the hopper moults from the third into the fourth instar. Consequently, it would appear that the mechanism of this regulation is set into motion sometime in the middle or late third instar, and, in some cases at least, it is likely to prove to be of a hormonal nature. The biological significance of these changes is obscure.

Summary

1. Among locusts and certain other Acrididæ, several important directional changes as well as non-directional changes take place when the insect goes from the third into the fourth instar. One such directional change, however, occurs when the insect goes from the second into the third instar. The third instar, therefore, appears to have a special importance in the Acrididæ.

2. The directional changes involve morphological, physiological and behaviouristic features. The morphological features concern the elytron- and wing-rudiments and the growth coefficients of the body and certain of its parts ; the behaviouristic features refer to locomotor activity, both spontaneous and induced ; while the physiological features concern respiratory metabolism. The non-directional changes described here refer to extra-moulting.

3. It is suggested that these changes are governed by an automatic regulation whose mechanism is set into motion usually in the middle or later part of the third instar. Available evidence points towards three types of such regulation, *viz.*, (*i*) physiological regulation primarily influenced by the external environment ; (*ii*) physiological regulation not

so influenced; and (*iii*) genetical regulation not primarily influenced by the external environment. The biological significance of the directional changes is as yet obscure.

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ON THE BIOLOGY OF *CACOECIA SARCOSTEGA* MEYR. IN BALUCHISTAN

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INTRODUCTION

Cacoecia sarcostega Meyrick (Tortricidæ, Lepid.) is fairly common in Baluchistan and in recent years the extent of damage by its larvæ to fruit trees has increased so enormously that it has now become a pest of first rate importance. A brief account of this species was given by Pruthi (1938). But in view of its importance, the writer has made a detailed study of the biology of the insect during the last four years and the results are reported in this paper.

The writer feels indebted to Dr. H.S. Pruthi, Imperial Entomologist, New Delhi, for his criticism and valuable help in the presentation of the paper ; to Mr. A. M. Mustafa, Agricultural Officer in Baluchistan for his able guidance during the progress of the work ; to the Imperial Institute of Entomology, London, for the identification of the species, and to M. Sabir Janjua, Entomological Fieldman, Quetta, for his help in the field and laboratory.

DISTRIBUTION

The genus *Cacoecia* is pretty widely distributed throughout the world, but is especially common in temperate regions. In India, it is represented by about a dozen species of which a few have previously been recorded as pests of deciduous fruit trees. The larvæ of *C. pomivora* Meyr. were found boring apple fruit and rolling apple and rose leaves at Ramgarh, Kumaon Hills (Fletcher, 1920) ; the larvæ of *C. termias* Meyr. rolling apple leaves at Shillong (Fletcher, 1932) and those of *Cacoecia pruneticola* Meyr. attacking the leaves and fruits of peach, plum and apricot at Peshawar (Pruthi & Batra, 1938). *C. sarcostega* was collected for the first time in India by Fletcher at Mukteswar (7,300 ft.), Kumaon hills, and described by Meyrick (1924) as a new species. It was first recorded from Baluchistan by Pruthi (1938), where it is common in almost whole of the Quetta-Pishin district, Fort Sandeman (Zhob district) and Ziarat (Sibi district). It is also present at Mastung and Kalat. Other species of *Cacoecia* found in Baluchistan are *subsidiaria* Meyr., *philippa* Meyr. and *pomivora* Meyr.

FOOD PLANTS AND FEEDING HABITS

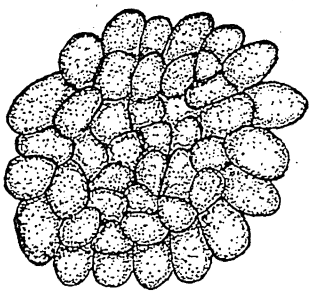
In Baluchistan, *Cacoecia sarcostega* is common on apple, peach, nectarine, apricot (*charmaghz*) and some valuable varieties of plums (mostly Santa rosa, *alubukhara*, Greengage and Crimson drop). But the larvæ have also been observed feeding on the leaves of cherry, pear, quince, mulberry, rose, ash, poplar, robinia and *chinar*, the incidence on these being very low.

On apple, the larvæ cause injury to buds, flowers, foliage and fruit. In April, when the buds begin to swell, the tiny overwintering larvæ crawl out of their hibernacula and eat their way into the centre of the buds where they feed on the developing flowers, thereby lessening the setting of fruit. They also web together the blossom clusters and thus spoil them. When a leaf is attacked by the larva, its petiole is severed and tied to the surface of another leaf by means of silken threads. A sort of nest is thus formed inside which the larva lives and feeds on the soft tissue between the veins. The infested leaves show skeletonized areas which increase in extent as the larva grows in size. Ultimately the leaves get dried up. Such dried-up clusters are quite conspicuous during May to September and can be seen even from a distance. It is very difficult to assess exactly the damage caused in this way, as almost similar damage is also simultaneously done by the larvæ of *Spilonota ocellana* Schiff. and other species of *Cacoecia*. In severe infestations about twenty to twenty-five per cent of the leaves are damaged by the larvæ. As regards fruit, the larva ties a neighbouring leaf to its surface by silken threads and feeds on the leaf tissue as well as the surface of the fruit. As a result thereof, the fruit is bruised, a corky scar or pimple develops over the wounds and its market value is decreased.

Unlike apple, of which buds, blossoms, leaves and fruits are attacked, the damage in the case of plum, apricot, peach and nectarine is caused mostly to the ripe fruit, though the foliage is also affected. When the fruit is about to ripen, the larva ties a fresh neighbouring leaf to its ripened portion by means of silken threads. In between the two, the larva lives, feeding first on the green portion of the leaf till it is almost skeletonized. Then it punctures the skin of the fruit, enters the pulp and starts feeding there. Ultimately a gum globule is formed between the leaf and the damaged portion of the fruit. As a result of this the fruit becomes unfit for consumption. Invariably a large percentage of fruit is spoiled and in some gardens the entire plum and nectarine crops have been ruined by the pest.

DESCRIPTION OF VARIOUS STAGES IN THE LIFE HISTORY

The Egg.—Eggs are laid in flat, irregular pale, green masses (Fig. 1) on the upper side of leaves, usually along the midrib or over one of the larger



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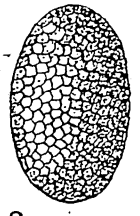

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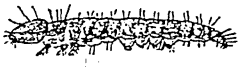

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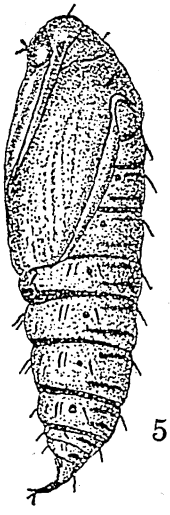

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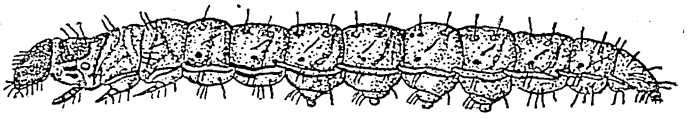

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FIG. 1. An egg mass ×10.
FIG. 2. An Egg ×25.
FIG. 3. Newly hatched larva ×10.
FIG. 4. Full grown larva ×4.
FIG. 5. The pupa ×6.

veins. A very thin, waxy coat is present over the whole of the outer surface of the egg mass. The average size of an egg mass is about 4×3 mm. but there is great variation in size and shape owing to the variable number of eggs comprising each mass. The average number of eggs per mass is about fifty but varies from sixteen to one hundred and ninety.

The egg (Fig. 2) is oval, flat and pale green in colour. The average length is 1 mm. and width 0.6 mm. The egg-shell is very thin and transparent and is traversed by a fine network of ridges which divides its surface into many irregular cells. Four or five days after the eggs are laid, the progress of the development of the embryo can be seen through the thin egg-shell. Just prior to hatching, the dark head of the larva can be seen clearly inside the egg, making the egg mass appear dotted with little black spots. The young larva finally emerges by cutting a slit in the chorion. The behaviour of the larvæ at the time of hatching is very interesting. In one mass of 68 eggs, ninety per cent of the larvæ emerged in less than ten minutes.

The Larva.—Almost immediately after hatching, the tiny larva moves about, nibbles here and there on leaf tissue and eventually starts constructing a small web-like shelter over itself, under cover of which it feeds. Later on the shelter takes the form of a tube, open at both ends, under a roof-like silken web. This tube is usually alongside the leaf vein, almost always on the underside of the leaf. As the larvæ grow, they web two leaves together and feed between them or web a leaf on to the surface of a fruit and feed on the skin and surface layer of the fruit. If disturbed when feeding, the larvæ usually drop very quickly from the leaves, moving backward with a quick wriggling motion and lowering themselves down by means of fine silken threads.

The number of instars and the moulting activities of the larvæ have been studied in detail and it has been ascertained that there are six larval instars in the Quetta Valley and the description of the various instars is as follows :—

First Instar (Fig. 3) :—Length soon after hatching 2.8 mm. to 3.1 mm. Head 0.5 mm. wide. General body colour pale green. Epicranium and frons dark, smoky brown, with the ocellar areas black, epicranial sutures deep black and prominent, adfrontal sutures indistinct. Mouth parts red-brown, antennæ and maxillæ somewhat pale. Thoracic shield shiny black. Tubercles raised, unicolorous with the body, each bearing a short yellow seta having a fine, dark ring at the extreme base. First pair of thoracic legs black ; the other two pairs, anal plate and prolegs concolourous with the body. Each proleg bearing 8 or 9 pale brown crotchets in uniordinal series. Spiracles indistinct.

Second Instar.—Length soon after moulting 4.1 mm. to 5.3 mm. Head 0.62 mm. wide. General body colour olive green. Epicranium, frons, maxillæ and antennæ of the same colours as in the first instar. Thoracic shield shiny black. Tubercles more distinct, prominent, unicolourous with the body, each furnished with a single hair. Each proleg bearing fourteen or fifteen golden-brown crotchets in uniordinal series. Spiracles darker and more prominent.

Third Instar.—Length soon after moulting 6 to 8 mm. Head 0.76 mm. wide. General body colour deeper than in the previous instar. Epicranium and frons dark brown to black, the former usually black on the ventral margin. Epicranial sutures black, adfrontal sutures indistinct. Mouth parts dark brown, antennæ with the first joint pale, except for a brown ring near the apex; the second joint light brown, paler at base and apex. First joint of maxillæ pale, with a light brown band near the apex. Second and third joints light brown. Maxillary lobes light to dark brown, with the apex pale. Thoracic shield dark brown. Tubercles more distinct, raised above and unicolorous with the body. Each tubercle tipped with brown and bearing a short seta. Each proleg bearing sixteen to eighteen crotchets in uniordinal series. Spiracles black and distinct.

Hibernation takes place in this instar.

Fourth Instar.—Length soon after moulting 9.2 to 11.4 mm. Head 0.9 mm. wide. General body colour yellowish green. Head of the same colour as in the previous instar, except that the darker areas on the antennæ, maxillæ and labium may be almost black instead of brown. Thoracic shield brown, bearing an anterior yellow band varying in width. Tubercles darker, tipped with black, each bearing a silky hair. Each proleg bearing twenty three to thirty crotchets in uniordinal series. Anal plate occasionally a shade darker than the rest of the body, though never really darker or prominent, furnished with long hairs. Spiracles raised, surrounded by a dark ring.

Fifth Instar.—Length soon after moulting 12 to 16 mm. Head 1.7 mm. wide. General body colour a shade darker than in previous stage. Head capsule of the same colour as in the previous stage, adfrontal sutures being now distinct. Tubercles tipped with black, each bearing a moderately long silky hair. Each proleg bearing thirty-one to thirty-seven crotchets in an irregular biordinal series. Spiracles raised, circular, with dark rim.

Sixth Instar (Full grown larva, Fig. 4).—Length soon after moulting 17 to 19 mm. but when full grown 21 mm. long. Width of the head capsule varying from 2 to 2.5 mm. General body colour extremely variable, dark green, yellow-green, pale gray-green, or light grass-green, yellow-green being most common. Epicranium sepia brown, sometimes somewhat darker ventrally, with the ocellar area black. Frons of the same colour as epicranium. Epicranial sutures black, very prominent, adfrontal sutures distinct. Clypeus pale white, labrum sepia-brown, mandibles darker at apex. Basal joints of antenna pale white, very small second joint long and black. Maxillary lobes light to dark brown, pale at apex. On the labium the prementum present as two dark brown lobes with a dark anterior band. Two dark chitinous areas near the base of the labium, surrounding the two big setæ arising therefrom. Rest of labium, except prementum brown and shiny. Thoracic shield of sepia brown colour. Dorsal surface of the body covered with pale tubercles, giving rise to setæ. First pair of thoracic legs sepia brown, other two pairs concolorous with the body. Claws of all legs brown. Prolegs concolorous with the body, each bearing fifty-two to fifty-seven crotchets in biordinal series. Anal plate lightly chitinized. Spiracles prominent, round and dark brown to black.

When the larva is about to pupate, it constructs a thin, white and elongate cocoon between the tied-up leaves. Inside this cocoon, the larva loses much of its colour until it is transformed into a pupa. Before pupating, the larva excavates a short passage in the cocoon for the pupa to wriggle out.

The Pupa (Fig. 5).—Length 9.89 to 10.2 mm., breadth 3 mm. across the wing covers on the third abdominal segment. Shape cylindrical, tapering posteriorly. General body colour yellow brown, darker on dorsal than on ventral side. Wing covers reaching the anterior ventral margin of the 4th abdominal segment. First and ninth abdominal segments free of any transverse row of spines, second with only one transverse row of spines about the middle of the segment, third to eighth each with one pair of rows of spines. Last segment prolonged with a strong curved brown cremaster having three hooked spines. Spiracles oval, raised, dark brown than general body colour. Abdominal segments bearing many yellow silky hairs.

When the moth is about to emerge, the pupa wriggles out of the cocoon from the narrow end. The case splits open and the adult moth emerges, leaving about two-thirds of the pupal case protruding.

The Moth.—The moths are active at dusk but during the day time they are sometimes seen sitting on stems and twigs and on the upper sides

of leaves. When viewed from above, the moth is bell shaped, the male being smaller than female. Meyrick (1924) has given detailed descriptions of both sexes.

DURATION OF VARIOUS STAGES AND SEASONAL HISTORY

As a result of investigations carried out by the writer during the last four years it has been ascertained that there are three generations of the insect in a year in the Quetta Valley.

First Generation

During 1936, the first eggs were deposited on May 3, but oviposition continued up to June 10. The dates during 1937, 1938 and 1939 were May 8, May 5 and May 10 and oviposition continued up to June 14, June 7 and June 16 respectively. The incubation period of the egg varied from 7 to 12 days with an average of 9.4 days. In 1936 it varied from 8 to 10 days, in 1937 from 7 to 11 days, in 1938 from 8 to 12 days, while in 1939 it was from 7 to 10 days.

During 1936, eggs commenced hatching on May 12 and continued to do so up to June 18. In 1937 hatching started on May 19 and continued up till June 21; in 1938 they commenced hatching on May 17 and continued up till June 15, while in 1939 hatching was in progress from May 20 up to June 23. The feeding period of larvæ ranged from 21 to 37 days, with an average of 30.8 days; in 1936 it was from 30 to 37 days; in 1937 from 24 to 31 days; in 1938 from 21 to 34 days, while in 1939 it was from 29 to 36 days.

At the end of the feeding period the larvæ seek sheltered places in the tied-up clusters, etc. and start spinning cocoons. The prepupation period, which begins from the time the larva stops feeding and ends with pupation, varied from 4 to 10 days, with an average of 8.2 days. In 1936 it varied from 4 to 9 days; in 1937 from 6 to 10 days; in 1938 from 5 to 9 days, while in 1939 it was from 6 to 8 days.

During 1936, the first pupation took place on June 20 and the last on July 17. The dates during 1937, 1938 and 1939 were June 22, June 24 and June 28 when first pupation was recorded and the last one was on July 19, July 17 and July 23 respectively. The pupal period varied from 10 to 15 days, with an average of 13.3 days. In 1936, it varied from 10 to 14 days, in 1937 from 11 to 15 days, in 1938 from 12 to 13 days, while in 1939 it was from 10 to 15 days.

In 1936, the first moths of the first brood emerged on July 2 and the last on July 31. The dates of first emergence during the three subsequent years were July 5, July 8 and July 9 and emergence continued up to July 29, August 1 and August 4 respectively. The length of the life

of the adult fed on glucose syrup in laboratory varied from 6 to 10 days. the average being 8.6 days during July-August, 1938.

Copulation takes place soon after the adults emerge. It lasts from an hour to an hour and a half, and invariably takes place at night. The preoviposition period varied from 2 to 5 days, with an average of 3.8 days. The average time of egg deposition was 5.98 days, varying from 3 to 8 days.

The egg-laying activities of the moth were observed in detail. Oviposition usually occurs either early in the morning or just after sunset. As the time for oviposition approaches, there are indications of excitement on the part of the female. After sometime she becomes quiet and selects a place on the upper surface of the leaf where she rests. She slowly lifts the tip of her abdomen and lays an egg mass. After laying an egg mass, she moves to another place on the same leaf, leaving a few hairs of the tip of her abdomen sticking around the egg mass. The average number of eggs deposited per female moth of the first brood was 297.7—ten females depositing 2,977 eggs. The maximum number of eggs deposited by a single female was 365 laid in 8 batches.

Second Generation

During 1936, the first eggs of this brood were deposited on July 5 and oviposition continued up to August 2. The dates during 1937, 1938 and 1939 were July 8, July 9 and July 12 and oviposition continued up to August 1, August 5 and August 7 respectively. The incubation period of the eggs varied from 4 to 9 days, with an average of 7. 10 days. In 1936 it varied from 5 to 9 days, in 1937 from 5 to 8 days, in 1938 from 4 to 9 days, while in 1939 it was from 5 to 7 days.

During 1936, eggs commenced hatching on July 14 and continued up to August 7. In 1937, hatching started on July 16 and continued up to August 6; in 1938 they commenced hatching on July 18 and continued up till August 9, while in 1939 hatching was in progress from July 19 to August 12. The feeding period of larvæ ranged from 20 to 29 days, with an average of 25.9 days; in 1936 it was 20 to 29 days, in 1937 from 22 to 30 days, in 1938 from 20 to 26 days, while in 1939 it was from 24 to 28 days.

The prepupation period varied from 3 to 8 days, with an average of 5.8 days. In 1936 it was from 4 to 8 days, in 1937 from 3 to 7 days, in 1938 from 5 to 7 days, while in 1939 it was from 5 to 6 days.

During 1936, the first pupation took place on August 8 and the last on September 2. The dates during 1937, 1938 and 1939 were August 10, August 6 and August 12 when first pupation was recorded and the last one in the three years was on September 3, September 5 and September 8

respectively. The pupal period varied from 6 to 10 days, with an average of 8.1 days. In 1936 it varied from 7 to 9 days, in 1937 from 7 to 10 days, in 1938 from 6 to 8 days, while in 1939 it was from 6 to 10 days.

In 1936, the first moths of the 2nd brood emerged on August 17 and the last on September 9. The dates of first emergence during the three subsequent years were August 20, August 14 and August 22, and emergence continued up to September 12, September 15 and September 10 respectively. The length of life of the adult fed on glucose syrup in laboratory varied from 6 to 9 days, the average being 7.8 days during August-September, 1939.

The preoviposition period varied from 2 to 5 days, with an average of 3.4 days. The average time of egg deposition was 5.7 days, varying from 3 to 7 days. The average number of eggs deposited per female of the second brood was 234.4, ten females depositing 2,344 eggs. The maximum number of eggs deposited by a single female was 326 laid in 6 batches.

Third Generation

During 1936, the first eggs of the 3rd generation were deposited on August 20, but oviposition continued up to September 15. The dates during 1937, 1938 and 1939 were August 23, August 16 and August 25 and oviposition continued up to September 17, September 20 and September 12 respectively. The incubation period of the egg varied from 8 to 12 days, with an average of 10.3 days. In 1936 it varied from 9 to 10 days, in 1937 from 8 to 11 days, in 1938 from 9 to 12 days, while in 1939 it was from 8 to 11 days.

During 1936, eggs commenced hatching on September 1 and continued up till September 27. In 1937 hatching started on September 4 and continued up till September 29 ; in 1938 they commenced hatching on August 28 and continued up till September 30, while in 1939 hatching was in progress from September 6 to September 23. The feeding period of the larvæ of this brood before going into hibernation ranged from 25 to 32 days, with an average of 28.9 days ; in 1936 it was 27 to 31 days, in 1937 from 26 to 32 days, in 1938 from 25 to 30 days, while in 1939 it was from 27 to 29 days.

On the onset of autumn, the larvæ begin to desert the leaves and go into hibernation. The earliest date on which the larvæ were found entering hibernation in 1936 was October 2, in 1937 it was October 4, in 1938 it was September 30, while in 1939 it was October 1.

The partially grown larvæ pass the winter in tiny silken nests or hibernacula which are very similar to those formed by *Spilonota ocellana* Schiff. These hibernacula are invariably seen under bud scales, in the

angle at the base of a fruit spur or a short twig, in a crevice in a bark or in any other convenient shelter near the dormant buds. These nests are usually 4-6 mm. long and vary greatly in shape, some being straight, others curved to conform to the space in which they are constructed. The hibernacula are always found in masses. The inner lining of the nest is white and quite tough in texture, while to the outside, bits of grass, tiny pieces of bark or bud scales are attached which make it almost resemble the bark and thus indistinguishable from the surroundings.

Securely enclosed inside the hibernacula, the larvæ pass the winter and with the approach of spring (April) when the flower buds begin to open and the development of the tender young foliage starts, they become active and come out of the hibernacula. In 1937, the first larva emerged on April 2 and the last on April 28 ; in 1938 the first larva came out on April 7 and the last on April 29 ; in 1939 emergence started on April 5 and continued up to May 1, while in 1940 the first larva emerged on April 3 and the last on April 26. The length of time spent by the larvæ in hibernation ranged from 182 to 198 days, with an average of 189.9 days. During 1936-37 it was from 182 to 190 days, in 1937-38 from 185 to 196 days, in 1938-39 from 183 to 192 days, while in 1939-40 it was from 184 to 198 days.

On emerging from their winter quarters the larvæ attack flower buds, young leaves, etc. The feeding period of these larvæ ranged from 20 to 28 days, with an average of 25.3 days.

The prepupal period varied from 5 to 8 days, with an average of 6.7 days.

During 1937, first pupation took place on April 24 and the last on May 19. The dates during 1938, 1939 and 1940 were April 27, April 25 and April 29 when first pupation was recorded and the last one was on May 23, May 20 and May 25 respectively. The pupal period varied from 12 to 15 days, with an average of 14.2 days.

In 1937, the first moths of the third brood emerged on May 6 and the last on June 5. The dates of first emergence during the three subsequent years were May 9, May 8 and May 14 and emergence continued up to June 12, June 9 and June 14 respectively. The length of life of the adult fed on glucose syrup in laboratory varied from 7 to 10 days, the average being 8.2 days during May-June, 1939.

The preoviposition period varied from 2 to 5 days with an average of 3.9 days. The average time of egg deposition was 6.2 days, varying from 4 to 8 days. The average number of eggs deposited per female moth of the third brood was 259.6—ten females depositing 2,596 eggs. The maximum number of eggs deposited by a single female was 347, laid in seven batches.

The life history data may be summarized as follows :—

Stage in life history	1st Generation			2nd Generation			3rd Generation		
	Max. (days)	Min. (days)	Aver. (days)	Max. (days)	Min. (days)	Aver. (days)	Max. (days)	Min. (days)	Aver. (days
Incubation period of eggs	12	7	9.4	9	4	7.10	12	8	10.3
Feeding period of larvæ (1st and 2nd generation only)	37	21	30.8	29	20	25.9	—	—	—
Feeding period of larvæ before going into hibernation (3rd generation only)	—	—	—	—	—	—	32	25	28.9
Hibernation period of larvæ (3rd generation only)	—	—	—	—	—	—	198	182	189.9
Feeding period of overwintering larvæ (3rd generation only)	—	—	—	—	—	—	28	20	25.3
Prepupal period	10	4	8.2	8	3	5.8	8	5	6.7
Pupal period	15	10	13.3	10	6	8.1	15	12	14.2
Life of adult moth	10	6	8.6	9	6	7.8	10	7	8.2
Pre-oviposition period	5	2	3.8	5	2	3.4	5	2	3.9
Number of eggs deposited per female	365	128	297.7	326	112	234.4	347	121	29.6

PARASITES

Perisierola sp. (Bethylidæ) has been found to parasitise the larvæ and *Brachymeria intermedia* Nees (Chalcididæ) and *Dibrachys cavas* Wlk. (Pteromelidæ) have been recorded attacking the pupæ of *C. sarcostega* Meyr.

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EUBORELLIA STALI DOHRN (FORFICULIDAE) AS A PEST OF GROUNDNUT IN SOUTH INDIA

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INTRODUCTION

Groundnut (*Arachis hypogoea*) is one of the important oil-seed crops in South India. It is subject to the attack of a number of insect pests of which the most important are the two leaf-eating caterpillars—*Amsacta albistriga* Walker and *Stomopteryx nerteria* Meyrick. So far, there is no record of any insect attacking the underground pods of this crop. In September, 1938, however, the authors noted the earwig, *Euborellia stali* Dohrn, feeding on the kernels of the pods at Coimbatore. As this appears to be the first notice of an earwig attacking crops in India, a study of the habits of the species was made and the following is a short account of the same.

Euborellia stali Dohrn is generally mistaken for another earwig, *Anisolabis annulipes* Lucas. The former resembles the latter in size, color and form but can be distinguished by the presence of narrow but perfectly distinct lateral flaps on the mesonotum. A description of the earwig is given by Burr in the *Fauna of British India, Dermaptera*, pp. 88-89 (1910).

LIFE HISTORY

The adults pair in 7-10 days after emergence. The females start egg-laying 10-23 days after pairing.

The Egg.—Eggs are laid in clusters in the soil and in pods. The freshly laid egg (Fig. 4a) is pearl white and oval in shape and measures 0.899 mm. long and 0.736 mm. broad. Just before hatching, the egg (Fig. 4b) bulges out at one end and is 1.25 mm. long and 0.979 mm. broad. The egg period ranges from 7-11 days. Seven females laid 139, 108, 80, 70, 68, 27 and 21 eggs respectively under laboratory conditions, with an average of 58 eggs. The maximum number of eggs found in a cluster was 28 and the minimum 2, the average for 32 clusters being 12.7.

The Nymph.—There are five instars. The newly hatched nymph is white ; it gradually becomes pale brown and measures 3 mm., with antennæ also 3 mm. and forceps 0.5 mm. in length. The antenna (Fig. 5) consists of

a series of joints. There is only one white joint preceded by one black at the apical end. The sexes can be distinguished by the number of abdominal segments ; the male has ten segments while the female has only eight segments. The first instar lasts 6-21 days. The nymph just

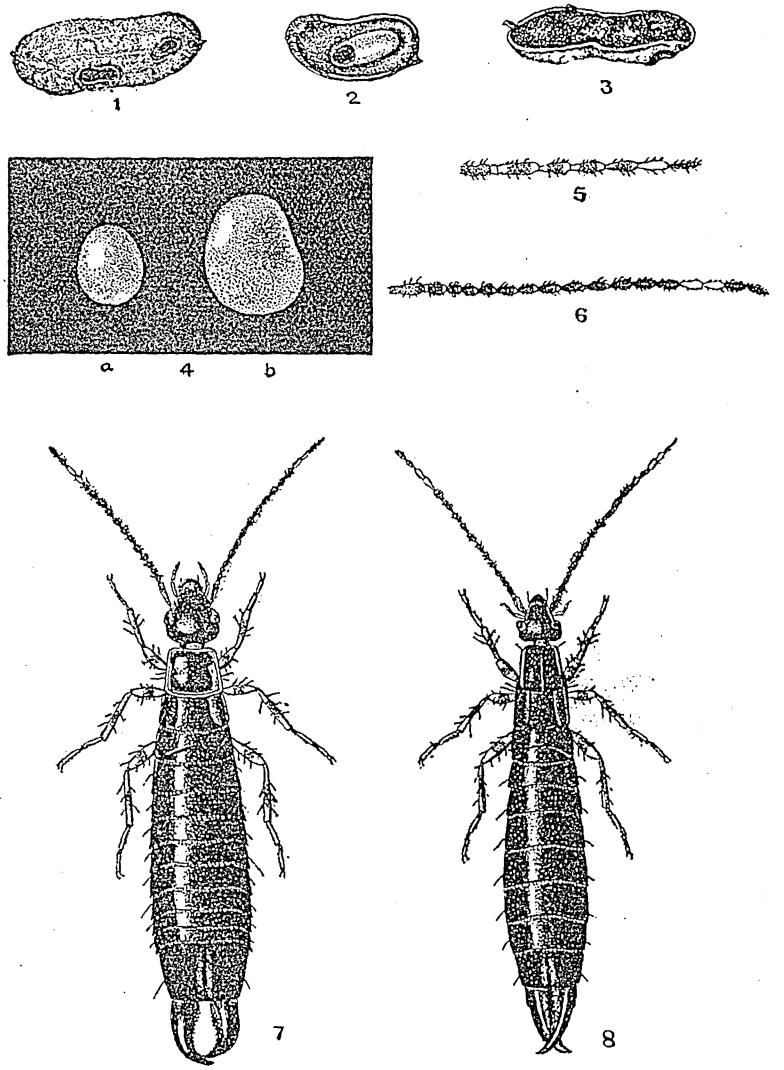

FIG. 1—3 damaged groundnut pods.
FIG. 4a freshly laid egg, fig. 4b egg just before hatching.
FIG. 5 antenna of 1st instar nymph.
FIG. 6 antenna of 4th instar nymph.
FIG. 7 male adult.
FIG. 8 female adult.

after the first moult measures 3.5 to 4.5. mm. and its antenna 2.5 to 3.5 mm. and forceps 0.5 mm. It has ten antennal segments including the pedicle, with one white joint preceded by one black joint at apical end. The second instar lasts 3-16 days. The nymph after the second moult measures 4.5 to 6 mm., with antenna 3.5 to 4 mm. and forceps 0.75 to 1 mm. in length. The antenna consists of 12 joints including the pedicle. There are now two white joints preceded by one black joint at the apical end. The third instar lasts 4-16 days. The nymph after the third moult measures 5.5 to 8 mm. with antenna 3.5 to 4 mm. and forceps slightly over 1 mm. and less than 1.5 mm. in length. There are now 14 (sometimes 15) antennal joints including the pedicle with two (sometimes three) white ones preceded by one black joint at the apical end. The fourth instar lasts 6-13 days. The nymph soon after the fourth moult measures 7.5 to 9 mm., with antenna 3.5 to 5 mm. and forceps 1.5 mm. in length. Now the antennal joints are 15 to 16 in number including the pedicle and there are two or three white joints preceded by two black joints (Fig. 6). The fifth instar lasts 6-16 days.

Adults.—The nymph after the fifth moult assumes the adult form having wing flaps. The antenna is 4 to 5.5 mm. and forceps 1.5 to 2 mm. in length.

The adults are fairly long lived. Seven females lived for 106, 133, 163, 167, 172, 233 and 252 days respectively. The first five laid eggs while the last did not lay any egg.

The total life cycle from egg to adult ranges from 56 to 72 days, the average period for 15 specimens of both sexes being 61 days.

Food habits

Earwigs generally feed on vegetable matter. During our observations they were found to feed on cabbage, cotton bolls and *sorghum* stems under field conditions. Under laboratory conditions they were fed on cabbage leaves. They showed cannibalistic tendencies also and hence it was found necessary to separate the male from the female into different cages soon after mating.

Distribution

Burr (op. cit) states that *Euborellia stali* Dohrn is a cosmopolitan insect. It is found in Bombay, Karachi, Madras and Pondicherry in India. This earwig is now found distributed also in Coimbatore and South Arcot districts. It is likely it may be more widely distributed in Southern India.

Nature and extent of damage to groundnut pods

This earwig bores into tender pods and feeds on the kernels. Counts of the attacked pods taken at the time of harvest of groundnut in different

fields for the year 1939 at Palur, Tindivanam and Coimbatore have given the following percentages of infestation :—Palur—2.7 : to 6.1 ; Tindivanam—6.2 to 13.5 ; and Coimbatore—9.6 to 19.95.

ACKNOWLEDGMENT

The authors are thankful to the Imperial Institute of Entomology, London, for identifying the insect.

SUMMARY

Generally earwigs are considered to be beneficial insects. The authors have, however, come across a species of earwig—*Euborellia stali* Dohrn—infesting groundnut pods in Coimbatore, Palur and Tindivanam in the Madras Presidency. This is the first record of an earwig attacking economic crops in India, though another earwig *Forficula auricularia* Linn., is known to be a pest of garden flowers e.g. dhalias, chrysanthemums, etc., in Europe. *Euborellia stali* Dohrn completes its life cycle in 56-72 days in Coimbatore. The maximum number of eggs laid by a single female was 139 and the maximum longevity 252 days. The earwig bores into the tender pods and feeds on the kernels. The infestation of pods ranged from 2.7% to 19.95%.

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A SURVEY OF THE INSECT FAUNA OF AFGHANISTAN

PART. I. GENERAL FEATURES OF THE COUNTRY AND ITS FAUNA

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CONTENTS

I. INTRODUCTION

In June 1939, the Government of India sent an Agricultural Delegation consisting of Mr. A. M. Mustafa (leader), Dr. B. B. Mundkur (Mycologist) and the writer (Entomologist) to Afghanistan for studying the agricultural conditions of the country, suggesting means and methods for its development and indicating ways by which the two countries could mutually help each other. The Delegation toured the country for about three months and submitted a general report to Government. In this paper and those which will follow in this series, it is proposed to give a scientific account of various insects collected in Afghanistan, with notes on their distribution, habits, etc. One of the striking features of the insect fauna of the country is that it is extremely variable from place to place. This is chiefly due to the diversities of climate to which the country is subject and its physical configuration. A few hours journey from Kabul (a temperate locality) will take the visitor to a region seething with insect species characteristic of a tropical or subtropical region and an hour's drive from Kabul will find him among almost Alpine fauna. This being so, it seems necessary to give a detailed account of the country's geographical, physical and climatic features and indicate the various natural divisions having more or less distinct sets of environmental conditions. This contribution is therefore devoted to a general account of the country in relation to the insect fauna. With this background it is hoped that it will be possible to appreciate properly the nature and distribution of the insect fauna of the country, which is so intimately dependent on climate and flora.

Besides the above a general account of various groups of insects met with in different ecological regions is also given in this communication. These specimens were collected from nearly one hundred different localities during a journey of over 3,000 miles. A detailed account of all the species of different orders will follow, when the material has been fully examined and identified by my colleagues who are interested in various groups.

II. PREVIOUS INSECT SURVEYS OF AFGHANISTAN

Owing to Afghanistan's isolation from other countries and therefore difficulty of its accessibility from without, together with lack of easy means of communication within, the insect fauna of this interesting country has been little explored. Whatever limited knowledge we have, is due to the meagre collections made by a few visitors who went there on political or other similar missions.

One of the earliest collectors of insects of this country, was Major H. Roberts who collected Lepidoptera from Rokeran near Kandahar. His collection was worked out by Butler (1880) who reported 28 species, of which five were new to science.

Col. Swinhoe collected a good number of Lepidoptera during the period (1880-81) he spent in field service between Sibi (Baluchistan) and Kandahar (Afghanistan). This collection was also examined by Butler (1881 & 1882). Later, Swinhoe (1885) himself published an up-to-date list of insects of South Afghanistan, including those collected by previous workers. Excluding the species of North-west India he reported 93 species, of which seven were new.

About the same time, Dr. Aitchison (1885), Naturalist attached to the Afghan Delimitation Commission, brought a good zoological collection, of which insects comprised about 100 species, 20 being new.

Von Heydon's contribution (1894) on the coleopterous fauna of Afghanistan is based on a collection procured by the Director of the Botanic garden, St. Petersburg, through a gardener domiciled on the border of Turkistan.

Recently (1935) the German Hindukush Expedition under the leadership of Dr. Scheibe carried out a botanical survey of a part of Afghanistan with a view to finding the origin of plant species and the relation between the wild and cultivated varieties of plants. During this survey they also made a small collection of insects, particularly Coleoptera and Heteroptera. About 115 species of which 25 are new, have been worked out and reported on by various specialists [*Arb. Morph. Taxon. Ent.*, **3** : 173-213 ; **4** : 177-191 ; **5** : 1-8 (1936-38)].

From this brief account of the entomological surveys of Afghanistan, it will be noted that almost all the collectors were amateurs who collected insects either as a hobby or because they were requested by others to do so in addition to their main duties. Naturally therefore, mere occurrence of various insect species—almost invariably those of adults which alone were collected—is all that is recorded. It is true that such information is of some value in understanding the geographical distribution and in some cases the origin of various insect species, but it throws no light on the more important questions such as the range of host plants of various species, nature and extent of their damage, their migration into neighbouring countries, etc. It is this aspect of insect survey of Afghanistan giving particular information about the immature stages of insects and the host plants attacked, which will be described for the first time in this communication and those which will follow in this series.

III. Method and technique of collection

At every locality visited in the country, as many plants as possible, particularly those of economic importance were examined. All insects of apparently one species from the same host plant were given one number. But even the same species from different host plants or from different localities received separate reference numbers. Each lot of insects with its proper number was put away in a separate tube or pill box and full notes regarding locality, nature and extent of damage, etc., were recorded under respective reference numbers. This did away with the necessity of putting long labels in the tubes and was found to be a very convenient method of keeping records of insects collected.

The adult insects were killed straight away and either preserved in spirit or kept dry. For instance, moths and butterflies were kept in paper envelopes with their wings pressed against each other. Although pinning and setting appliances had been taken by us, no setting work could be done as the party was almost constantly on the move.

The immature stages were dealt with in a different manner. A few of these, if they were fairly common, were preserved in 70% alcohol. The rest were kept for rearing in glass-topped pill boxes, so as to get the adult stages. In case the number of immature stages of an insect was limited, only notes were taken on their general form, shape, colour, etc., and all were kept alive for rearing.

The rearing of immature stages presented many difficulties. As almost every day the party moved to a new locality, it was often found difficult to obtain the food plants for the insects collected at the previous localities. They had to be either specially sent for, or alternate food plants had to be tried or else the insects had to be left to starve and die. It was

further found that the pupæ of many Lepidoptera were very sensitive to shaking and jolting, which was unavoidable in view of the condition of roads in the country. Nevertheless it is gratifying to state that over 50% of the immature specimens were successfully reared and thus made identifiable.

IV. GEOGRAPHIC, CLIMATIC AND VEGETATIONAL FEATURES OF THE COUNTRY

Afghanistan may generally be regarded as a high quadrilateral plateau, lying between 29°30′ and 38°30′ N and 60°30′ and 57°E. Even the lowest portion of the country, the lake of Seistan in the south-western corner is much above the sea level (1280′). Its total area is estimated at about 250,000 square miles and the population at about 7,000,000 according to the 1937 census. The country is roughly 770 miles long from south-west to north-east with a width of about 525 miles, from the Amu river to the extreme south (map on the next page).

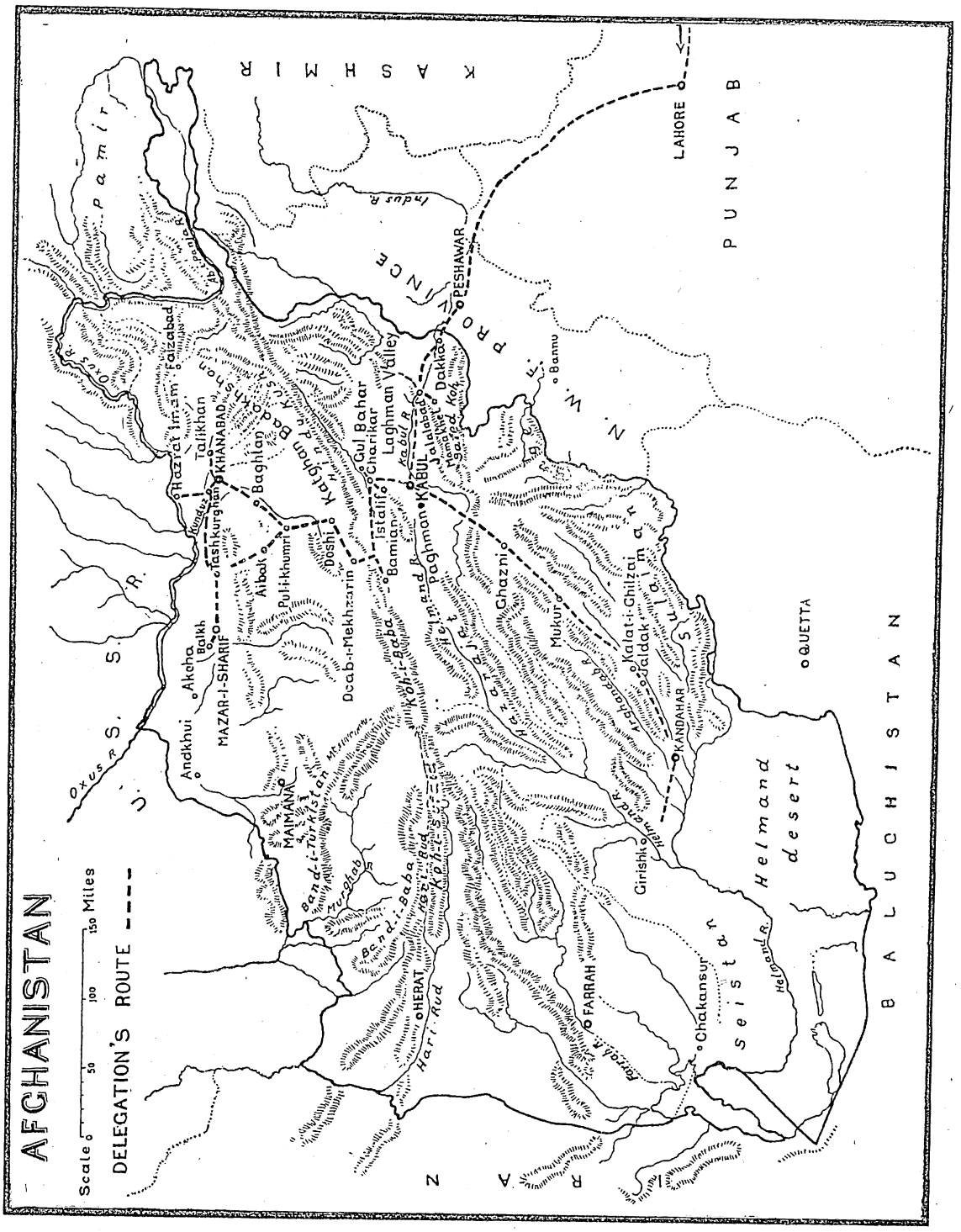
Physical features

The most important mountain range, the Hindukush is a continuation of the Himalayas and originates from the perpetually snow-clad region of Pamir in the north-east corner, familiarly known as the " Roof of the world ". This mountain range bends down in the form of an arch and then proceeds westwards right across the country separating the basin of the Oxus river on the north from that of the rivers Kabul and the Helmand on the south. The main ridge of the Hindukush is about 20,000 ft. high, with numerous peaks reaching up to 25,000 ft. The remaining mountain ranges of the country may be described as the rays of a fan radiating from the above mentioned main range. Beyond Kabul, the main range is known as Koh-i-Baba (10,000 -17,000 ft. high). Further west, it gives off three main branches called Band-i-Turkistan, Band-i-Baba, and Sufaid Koh from north to south respectively. They enclose between them the fertile valleys of the rivers Hari Rud and the Murghab which drain into deserts of Turkistan in the north.

Another ray of the fan traverses southwards through major portion of central Afghanistan (Hazarajat) and extends as far as Kandahar and Farrah. This encloses the valleys of rivers Helmand, the Arghandab, the Farrah, etc.

Finally, the Suleiman range runs along the eastern boundary of the country giving inward off-shoot called Spinghar (Safed Koh), northern and eastern spurs of which lie between Kabul and Jalalabad and between Jalalabad and Peshawar (Khyber pass) respectively.

It will thus be noticed that most of the country is traversed by mountain ridges, the flat tract being about a quarter of the entire area,


AFGHANISTAN
Scale 0 50 100 150 Miles
DELEGATION'S ROUTE
KASHMIR
PUNJAB
BALUCHISTAN
Helmand desert
Seistan
Pamir
Indus R.
Oxus R.
Hari Rud
Helmand R.
Farah Rud
Kabul R.
LAHORE
PESHAWAR
Bannu
N.W.F. PROVINCE
Khyber Pass
Jalalabad
Dakka
Gul Bahar
Charikar
Laghman Valley
KABUL
Logar R.
Paghman
Istalif
Bamian
Doshi
Deab-i-Mekhzarin
Kotal-i-Shibar
Ghazni
Mukur
Kalat-i-Ghilzai
Zaldak
KANDAHAR
QUETTA
Arghandab R.
Tarnak R.
Girishk
Chakansur
FARAH
HERAT
Kohsan
Band-i-Baba
Band-i-Turkistan
MAIMANA
Andkhui
Akcha
Balkh
MAZAR-I-SHARIF
Aibak
Pul-i-khumri
Tashkurghan
Khanabad
Kunduz
Talikhan
Faizabad
Ghazni Irrigation
Baghlan
Kataghan
Badakhshan
Oxus R.
U.S.S.R.

possibly even less. This comprises (*i*) the plains of Afghan-Turkistan in the north of the Hindukush range, (*ii*) the lower basins of rivers Murghab and Hari Rud and of Farrah Rud in the north west and west giving space to the provinces of Herat and Farrah, (*iii*) the lower parts of rivers Halmand and Arghandab (Kandahar province) and the desert Seistan to the south west of Kandahar, and (*iv*) the Laghman and Jalalabad valleys in the eastern region of the Kabul basin.

Rivers

Owing to the mountainous nature of the country, rivers of Afghanistan are mostly tumultuous torrents rushing at tremendous speed through deep gorges but getting used up to a large extent as they flow through the lower dry plain areas. Though most of the rivers are not navigable, they possess great potentialities for irrigation and generation of electric power. They bring down vast amount of silt and other sediment and thus act as natural fertilizers of their lower basins which are consequently very rich and fertile.

The three great rivers of the country are the Oxus, the Helmand and the Kabul. The Oxus forms a natural boundary on the north between Afghanistan and Russia for over 400 miles. Its basin occupies the entire breadth of northern Afghanistan which includes the provinces of Qatghan-Badakhshan, Mazar-i-Sharif and Maimana. The Helmand river with its tributaries drains whole of south Afghanistan. Its source lies in the Paghman range, a southern offshoot of the Hindukush, not far on the west of Kabul. It flows a long distance through scraped rocks and central highlands of Hazara till near Girishk it opens into a more or less flat country which it irrigates. About 45 miles further south it is joined by the Arghandab, coming from Kandahar and then enters a desert area finally terminating in the lake of Seistan.

The Kabul river originates about 30 miles east of Kabul by receiving several streams from Unai pass, Ghorband valley, etc. Lower down it gets Alishang from Laghman valley on the left and numerous small tributaries from the Spinghar range on the right. A marked natural division of the Kabul basin takes place at Gandamak near Jalalabad, by a fall in the general level of the valley from 5000 ft. to about 2000 ft. Finally the river flows into the plains of Peshawar and joins the Indus near Attock, in British India.

Climate

The climate of Afghanistan is as diversified as its physical features, this being more due to differences in elevation than its geographical position. Situated in the north temperate zone but far removed from the

moderating influence of the sea, Afghanistan has generally a continental type of climate. Its remarkable features are an extreme range of temperature between summer and winter, day and night, and sun and shade, combined with little rainfall and dry winds. There is a great climatic variation in different parts of the country, ranging from an alpine in the north eastern Pamirs and the Hindukush to a hot and dry in the deserts of south west.

In the plains on the north of Hindukush, winters are fairly cold, while in summer the temperature is as high as 110°-112°F. From May to November the minimum temperature remains above freezing point. At Kabul and the high plains up to the descent at Gandamak, winter is rigorous. Snow lies for two or three months and people sleep close to heaters. The summer days are warm and bright, the nights fairly cool, necessitating sleeping indoors. Monthly mean temperatures (°F) at Kabul for some typical months are :—

Jan.	May	July	Nov.
31.4	67.4	72.2	51.2

Beyond Gandamak, *viz.*, in Jalalabad and Laghman valleys, climate approximates to that of Indian plains and hot weather sometimes brings *samum* winds. All over the Kandahar province, summer heat is intense ; in winter snow seldom falls and if it does, it soon melts. Herat, though 800 ft. lower than Kandahar has a more temperate summer, the maximum temperature often remaining between 90° to 93°F, rarely touching 98°F. Winter is also mild. Snow melts as it falls and even on mountains does not lie for long.

Rainfall

Afghanistan lies outside the influence of the south-west monsoon, therefore rainfall in summer is very scarce. Monsoon, however, brings a limited amount of rain to the eastern parts, up to the Laghman valley. The country gets much of its precipitation as winter snow and a small but useful rain in spring. Thus the atmosphere is generally dry, and brilliant sunshine over large part of the year with bright clear nights is the chief feature. Average rainfall at Kabul is 10″-15″.

Natural and floral divisions of the country

The flora is very much dependent upon the climatic conditions to which various parts of the country are subject. On the whole, it may be stated that the cold and rigorous winters, the moist springs, the bright hot summers and dry windy autumns render the country

suitable for a vegetation which is mainly annual. If perennial, it consists of tap-rooted species which give forth annual leafy shoots during spring and summer. The wild flora of the country is generally xerophytic, that is, it consists of desert plants chiefly of Persian and Arabian types.

Leaving aside the high mountain ranges which are for the most part covered with snow, the rest of Afghanistan may be divided into the following natural divisions :—

(*i*) *Laghman and Jalalabad valleys.*—The lower basin of the Kabul river up to Gandamak is generally below 3,000′. Its climate is very similar to that of the N.W.F. Province of India, the summers being hot, the winters fairly cold. The monsoon winds give some rain to this area during the summer months. The valleys have abundant supply of river water and are densely populated.

Tropical crops like sugarcane, rice and melons are extensively cultivated. Laghman rice and melons are noted for their quality throughout Afghanistan. At the time of our visit (June) wheat had just been harvested. Among pulses, the bean, *Vicia fabia* var. *minor* and *Vicia ervilia* were fairly common. Seedless pomegranates of good quality grow in districts of Gandamak and Jagdalik. Other fruit trees that grow well are citrus, date, loquat, plum and fig.

Edible pine, wild walnuts and fig grow abundantly in Nuristan.

The main ranges of Spinghar mountain in the south and Asmar in Nuristan are covered with dense forests of conifers. Between 6,000′ and 10,000′ heights grow large trees of *Cedrus deodara, Abies excelsa, Pinus longifolia, Pinus piaster, Pinus pinea* and *Larix communis.* Besides these, yew, hazel, juniper, walnut, wild peach and almond are also frequently seen. In the shade of these trees grow several varieties of rose, honey suckle, currant, gooseberry, hawthorn, and wild vine. At lower altitudes there are adler, ash, indigo, laburnum, wild olive, acacias, mimosas, barberry, wild palm and *Zizyphus.*

(*ii*) *The Kabul plateau.*—The elevation of the Kabul valley is between 4,000′ and 6,500′. It is bounded by still higher ranges of Hindukush and is watered by the Kabul river and its tributaries. It is one of the richest and most densely populated valleys. It is under snow for 2-3 months, but has warm and pleasant summers. There is one crop harvest in a year against two lower down at Jalalabad. In fact on our way to Kabul while we left wheat on the threshing floor at Jalalabad, we found the crop yet green and in the " milky " stage near Gandamak, only 25 miles distant.

Kabul and its environs are eminently suited for almond cultivation. There are also scattered gardens with a few peaches, apricots, cherries and grape vines. Poplar and willow abound everywhere and are perhaps

the most predominant. Wheat, lucerne, bean (*Vicia fabia* var. *minor*) and lentil (*Lens esculenta*) are common.

The Paghman valley situated about 18 miles west of Kabul is the summer resort of the Government. With an altitude of 7,300′, the valley is much cooler than Kabul and the entire hillside is dominated by snow-clad mountains and very well wooded. Poplar forms the main supply of timber, telegraph posts, etc. There are a number of orchards of apple, apricot, walnut, peach, plum, wild and cultivated cherry and willow. Several flowering plants such as rose, hollyhock, etc., are also common.

The Ghorband or Koh-i-Daman part of the Kabul plateau runs from Kabul along the main road to the north, passing through well populated towns of Dakoo, Serai Khoja, Charikar, Jabul Saraj, Istalif, Gul Bahar, etc., and ends in the high range of the Hindukush mountains. This road is almost throughout planted with mulberry trees which form a beautiful avenue. In fact mulberry seems to be the most common tree in this valley and its fruit forms the staple food of the people as it is eaten both fresh and dried in large quantities. Vineyards come next in importance and are seen enclosed by high walls throughout. Other fruit orchards are mostly around Istalif where there is a government garden having all kinds of deciduous fruit trees such as almond, apple, apricot, cherry, grape-vine, mulberry, peach, plum and pomegranate. Of the staple crops, wheat, gram, cotton and bean are common. Higher up, in the Bamian district, beans occupy a place only next to wheat. In the highlands of Kabul, edible rhubarb is an important plant growing wild. Walnut and edible pine are other wild growths. On the banks of the water courses, *Elaeagnus orientalis* is common and yields an edible fruit.

(*iii*) *Afghan Turkistan.*—That part of the great central Asian steppes extending from the base of the Hindukush to the Oxus river (*Amu Darya*) is termed Afghan Turkistan. It includes the provinces of Qatghan-Badakhshan, Mazar-i-Sharif and Maimana. Even Herat may be included in this for convenience. This region is a vast expanse of low-lying soil with average height of about 2,000′. Its major portion forms an immense pasture whereto swarms the livestock of the country during summer. The rest is arable land capable of being cultivated.

After crossing the Hindukush range, the area from Doab-i-Mekhzarin to Pul-i-Khumri is characterised by crops like wheat, maize, cotton and rice. Among fruits, almond, mulberry and apricot are the more important. At Baghlan further north, the Government have recently tried the cultivation of sugarbeet and have found that it contains as much as 18% sugar; therefore extensive areas are being put under this crop.

Khanabad, the capital of Qatghan-Badakhshan province is the centre of cotton-growing belt. Here cotton grows well, even without irrigation

(*barani*). Wheat, rice and melons are the other important crops. Among pulses, pea (*Pisum sativum*) is most common in this province although it is grown sparingly in the rest of Afghan Turkistan. The bean, *Vicia fabia* var. *minor* is frequently sown mixed with other crops, *e.g.*, barley, pea and *Lathyrus*. Poppy grown in the province shows a high opium content. With the possible exception of mulberry, fruits are not much in evidence.

From Kunduz to Tashkurghan the country is an extension of the vast Turkistan steppe where nothing except camel grass and *Artemisia* grows. Around Tashkurghan and Mazar-i-Sharif there are many gardens of pomegranate, apple, almond, peach, pear, apricot, mulberry and sometimes grape vine, while poplar and willow are common as hedge and roadside trees. Cotton is comparatively less on this side, but wheat and melon continue to occupy an important position. In fact this area produces some of the finest varieties of melons, while several wild forms grow as weed in maize and cotton fields, and sometimes along the river banks and roads. A good quality of tobacco is also cultivated. The Aibak valley about 3000 ft. above sea level is the chief centre of pistachio production, which grows wild in the large forests in this valley.

The Herat valley on the extreme west is fertile and well irrigated yielding two crops a year. In the old days it was called the " Granary of Central Asia ". Excellent varieties of wheat, barley for fodder and grain, maize, tobacco, saffron, and poppy are grown. Beans, lentil, alfalfa and pea cover nearly quarter of the cultivated area. Potato, tomato, onion and garlic are widely grown near towns. Besides other fruits, Herat produces fine varieties of grapes, pomegranates and sweet almonds. Wild pistachio, walnut and almond grow along the low hillocks.

(*iv*) *Hazarajat.*—This includes the region of central highlands between the Koh-i-Baba, the Spinghar, and the Sulaiman range, of which Ghazni may be called the typical representative. This region is higher than Kabul, with an elevation of over 7,000′. The summers are also fairly cold, while snow lies for several months in winter. It is thinly populated, having mostly gravel soil of little agricultural importance. However, some wheat, rice, maize, lucerne and cotton are cultivated, while clumps of usual poplar and willow occur everywhere. On lower hillocks several fruit trees are also grown among which pear, plum and apple are important, while mulberry forms an essential part of the orchards all over.

Good type of tobacco is grown at several places. *Prangos pabularia* is abundant and extends through the Hazara country to Herat. It is stored in winter and used as fodder.

(*v*) *South-Western Afghanistan.*—Major portion of south-western Afghanistan is a desert covering nearly a quarter of the country. The valleys of lower Helmand, the Arghandab, the Khash Rud and the Farrah Rud and the narrow strips around the lake lands are well cultivated. From Mukur to Kalat-i-Ghilzai along the main road to Kandahar one notices cultivation of wheat, barley, maize, lucerne, shaftal and melon, on a fairly large scale. The common lentil (*Lens esculenta*), bean (*Vicia fabia* var. *equina*) and rice are also grown in patches. This area is notable for numerous almond groves and vineyards, the cultivation of which is of a high order.

Kandahar is rightly called the fruit garden of Afghanistan. The Arghandab valley stretching for over 20 miles from the town is all under orchards, well supplied with water. The chief fruit trees are similar to those found in Baluchistan, *e.g.*, apple, pear, apricot, peach, plum, quince, nectarine, pomegranate, walnut, fig, almond, etc. Of these, a very sweet variety of apricots known as *shakarpara* and fine quality of pomegranate are well known. The eastern side of Kandahar less sufficiently supplied with water is under numerous vineyards, which produce large quantities of grapes. Of the staple crops, wheat, barley, maize and rice are grown. Madder is an important item of the spring crop. Tobacco and saffron are of much repute.

Pistacia khinjak grows wild in this area and affords a *mastic*. *Narthex assafoœtida* grows abundantly in high and dry plains in the west, particularly between Kandahar and Herat.

Several species of hawthorns, black berries, and currant grow wild. Wild water-melon is met with in the whole of Seistan desert, from Farah right up to the Iranian border. On the tableland near Kandahar and in less elevated valleys are found the Papilionaceous plants, the camel thorn, milk-vetch, *Astragalus*, and the spiny rest-harrow, fibrous roots of which are used as tooth brushes. Besides these, the sensitive *Mimosa*, rose-bay, wild laburnum and several kinds of orchids and salsola are also common. Reeds and rushes grow wild in marshes and along the banks of water courses.

V. Important insects found to be common in different regions of the country

It is not proposed to give here the distribution of all the insect species collected, nor their host plants, habits, etc., in detail, which as already stated will form the subject of subsequent contributions. Here only the important features of the insect fauna of different natural regions of Afghanistan are described in broad outline.

(*i*) The Laghman and Jalalabad valleys are characterised by the presence of insect species similar to those found in tropical and subtropical regions of north-western India. At Dakka a few miles from the eastern boundary, grubs of *Epilachna dodecastigma* Muls., were found skeletonising brinjal leaves in large numbers. Brinjal leaves were also being folded and damaged by caterpillars of *Euzophera punicella* Moore. The Chrysomelid beetle *Aulacophora foveicollis* (Lucas), was active on pumpkin leaves, while maggots of a fruit-fly, presumably *Myiopardalis pardalina* Bigot, (which could not be reared to the adult stage) were recovered from apparently sound pumpkin and melon fruits. Some Carabid beetles (*Pheropsophus catoirei* Dej.) were collected from a brinjal plot predating on different kinds of caterpillars. An interesting type of a large red ant was common in this area. It had its nest underneath stones. On coming out of the nest the worker ants moved about haphazardly instead of following a regular path usual with many species of ants. No granulated soil or dust was noticed around the entrance of the nest. Several specimens of *Pyrameis cardui* Linn., *Eumenis parisatis parsis* Le Cerf, and *Nomophila noctuella* Schiff. Wien. Verz. were collected on wing. They had a rather dull colouration, resembling very much the colour of the rocky environment from which they were not easily distinguishable when resting. A few specimens of the Mantid, *Statilia maculata* Thnbg., were collected near Dakka.

It is noteworthy that cotton crop, although putting forth flower buds and bolls was free from bollworms, so serious in several other cotton-growing countries of the world. Jassids so common and injurious in north-west India were found in small numbers only.

(*ii*) *The Kabul Plateau.*—As our stay at Kabul was longer than that at any other place in the country, there was an opportunity of surveying this valley rather thoroughly.

The most common insects in this region seem to be various species of Aphididæ. They are not necessarily the most injurious, but there was hardly any orchard which did not show signs of their damage. In the environs of Kabul the most important species were : *Anuraphis* sp., causing leafcurl on peach and iris., *Hyalopterus* sp., on peach, apricot and bamboo leaves, *Hyalopterus arundinis* (Fabr.) (?) on plum, *Chaitophorus* sp., on poplar leaves, *Macrosiphum pisi* (Kalt.), on berseem, *Macrosiphum rosæ* (Linn.), on rose and *Atheroides* sp., on wild grass. Other sucking insects in this area included whiteflies on rose, Jassids on brinjal, the pear *Psylla* on pear leaves, and some Tingid bugs on willow.

The most serious fruit pests were the codling moth (*Carpocapsa pomonella* Linn.), infesting upto 30% of apple fruits, and *Hyponomeuta padellus* Linn., defoliating several deciduous fruit trees, particularly apple, apricot, and

almond. The caterpillars of *Hyponomeuta* web the leaves together and feed inside, thus completely defoliating the trees. This is a European species not known from India so far. Other Lepidopterous species observed in this area were *Cacoecia pomivora* Meyr., folding leaves of rose, *Pyrameis cardui* Linn., defoliating hollyhock, *Plutella maculipennis* Curt., damaging young potato plants, *Plutella* sp., feeding on leaves and young shoots of cabbage, *Heodes phlaeas* Linn., on berseem, the leaf-miner, *Lithocolletis populiella* Filip. on poplar and *Pieris brassicæ* Linn., on several cruciferous crops. Besides these, adults of *Pieris rapæ* Linn., *P. daplidice moorei* Rob., *Nomophila noctuella* Schiff. and *Catocala afghana* Swinh., were also common.

The beetles were fairly well represented in this area. Chief among these were the Meloid beetles, *Mylabris damascena* Rch., feeding on flowers of mustard and other cruciferous crops, grubs and adults of *Plagiodera versicolora* Laich, seriously damaging willow and ash plants, the Chrysomelid, *Scelodonta* sp., and *Platymycterus afghanistanicus* Voss, feeding on poplar leaves, the Scolytid borer, *Polygraphus* sp., and the Cerambycid borer, *Xylotrechus smei* L. and G., under the bark of apple stem. A species of *Scymnus*, probably new, was bred from grubs feeding on *Hyalopterus* sp., infesting apricot.

It is noteworthy that the fruit-flies, so common in India, seemed to be absent. Several Syrphidæ were actively feeding on Aphids. Of these, *Syrphus confrater* Wied., was reared from maggots feeding on plum aphid (*Hyalopterus arundinis*) and *Lasiopticus latimaculatus* Brun., from maggots feeding on the apricot aphid.

Between Jalalabad and Kabul in the Sih Baba valley bounded by high mountains a few individuals of *Locusta migratoria, solitaria* R. and F., were noticed.

The Paghman valley at a little higher altitude has a somewhat different fauna. The Aphididæ were represented by *Hyalopterus* sp., on leaves of peach, *Chromaphis juglandicola* (Kalt.), and *Callipterus juglandis* (Frisch), on walnut leaves, *Aphis laburni* Kalt., and *Pterochlorus saligna* (Gmelin), on willow, a new species of *Pterocomma* sucking from poplar stem and branches, and of *Pemphagus* sp., causing serious galls on poplar. A species of *Macrosiphum* was common on a wild grass. Some Jassids on apple and rice were also collected.

It was here that the apple defoliator, *Hyponomeuta padellus* Linn., was most serious. Numerous trees of apple, apricot, almond, plum and cherry had been completely defoliated and had consequently borne no fruit. Leaves of hollyhock were being seriously damaged by caterpillars of *Carcharodus alceæ swinhœi* Watson (?) and *Pyrameis cardui* Linn., and of apple by caterpillars of *Spilonota ocellana* Schiff. The poplar shoots were freely

bored by *Sarrothripus revayana* Scop. The other notable Lepidoptera collected in small numbers on wing were *Coenonympha pamphilus* Linn. (?) *Colias hyale erate* Esp., *Polyommatus icarus fugitiva* But., and *Pieris rapæ* Linn.

The most common beetles were *Chrysomela populi* Linn. (adults) and *Plagiodera versicolora* (grubs and adults) on leaves of willow. They were being predated upon by the large Coccinellid, *Ithone hexaspilota* ab. *mirabilis* Motsch. The Cetoniid beetle, *Oxythyrea cinctella* Sch., was fairly common on rose flowers, *Platymycterus afghanistanicus* Voss, on leaves of hollyhock and rose, and the grubs and adults of *Apion æneum* F., seriously damaging roots of hollyhock. Some adults of *Synharmonia conglobata* L., and *Halyzia* sp. near *sedecim-guttata* L. (probably new) were noticed on willow and of *Coccinella undecim-punctata* L., on rice probably predating on aphids, those of *Cicindella bigemina* var. *brevis* Horn, swiftly running about on cool moist soil, and of *Gymnopleurus flagillatus* F., and *Onthophagus* sp., breeding under dung.

A large percentage of full-grown caterpillars and pupæ of *Hyponomeuta padellus* were found parasitised by several Chalcids, *viz.*, *Pteromelus puparum* (?) and species of *Monodontomerus* and of *Pleurotropis*. From the egg-cluster of a bug on apple leaves emerged large numbers of *Telenomus* sp. A Tachinid was actively parasitising larvæ of *Pyrameis cardui* Linn., infesting hollyhock, and the Syrphids, *Scæva albomaculata* Macq., *Paragus serratus* (Fab.), and *Ischiodon scutellaris* Fab., were common on various Aphids.

In the Ghorband valley the mulberry avenue had recently suffered seriously from an outbreak of a species of *Cicada*. Numerous cast skins were noticed on the trees, road side bushes and in holes in the soil. The Government garden at Istalif was suffering from an attack of *Anuraphis* sp., on peach and almond. *Eriosoma* sp., was causing galls on poplar and another species producing numerous galls on mulberry inflorescence where normally fruit should be formed. The codling moth larvæ in apple fruits, *Heliothis obsoleta* Fab., feeding on gram, *Hyponomeuta padellus* defoliating almond, apricot and apple, *Laphygma exigua* Hubn., and *Oliarus* sp., on berseem, *Macrosiphum pisi* on bean leaves, and a Fulgorid on apple leaves, were the other notable insects. The Coccinellid, *Adalia decempunctata* (L.), was a common predator on *Anuraphis* sp., infesting peach etc. Adults of *Scarabaeus gangeticus* Cast., and *Gymnopleurus miliaris* F., were found under soil.

It is noteworthy that the two most common plants namely, cotton and grape-vine, were almost entirely free of insect pests.

(*iii*) *Afghan-Turkistan.*—Situated at a low altitude, this area had insect fauna markedly different from that of Kabul plateau. Aphids

were extremely rare, and the codling moth and *Hyponomeuta padellus* seemed to be absent. Jassids on cotton and mulberry were present in small numbers. The other common sucking insects were the predaceous bug, *Pirates mundulus* Stal., and the water bug, *Corixa hieroglyphica* Duf., at Kundus; *Carpocoris fuscispinus* Boh., var. *coreanus* Dist., and *Eurydema festivum* L., f. *chloroticum* How., f. *decoratum* H.S., and f. *pictum* H.S., at Doab-i-mekhzarin; *Brachynema cincta* F., and *Lygus pratensis* L., at Aibak; and *Adelphocoris lineolatus* Goeze, at Mazar-i-Sharif. Of the Lepidopterous species, the leaf-minor, *Lithocolletis populiella* Filip, of poplar at Aibak, and a caterpillar boring into almond fruit (which could not be reared to the adult stage) at Tashkurghan were fairly common. The other interesting butterflies collected were *Polyommatus icarus fugitiva* But., at Khanabad; *Apopestes spectrum* Esp., and *Pieris daplidice moorei* Rob., at Mazar-i-Sharif; *Carcharodus alceæ swinhœi* Watson, at Tashkurghan; and *Rhodometra sacraria* Linn., *Laphygma exigua* Hubn.(?), *Apopestes spectrum* Esp., and *Nomophila noctuella* schiff. at Doab-i-Mekhzarin.

This region seems to be specially rich in Coleoptera. Of these, a Meloid beetle, *Epicauta erythrocephalus* Pall., was the most serious on sugar beet at Baghlan. This beetle does not seem to occur in India. Other beetles, occurring in sufficiently large numbers were *Epilachna dodecastigma* on melon creepers and *Oxythyrea cinctella* Sch., on dahlia flowers, while less common but otherwise important were *Coccinella septem-punctata*, *Coccinella undecim-punctata* Var. *menetriesii* Muls., *Adonia variegata* Goeze, and *Aetheomorpha* sp., at Baghlan; *Omophron rotandatus* Chd., *Plagiodera versicolora* Laich, *Epilachna dodecastigma*, *Adonia* sp., *Adoretus nitidus* Arr., *Philonthus* sp., *Scarabæus gangeticus* Cast., *Rhyssemus germanus* L., *Aphodius lividus* Ol., *Chaetocnema concinnipennis* Baly, *Heterocerus obliteratus* Kiesw., *Dryops jeanneli* Boll., *Bledius glasunovi* Luze, *Anthicus crinitus* Laf., and *Aphodius* sp., at Kundus; *Adalia decempunctata* L., *A. tetraspilota* Hope, *Stenolophus marginatus* Dej.(?), *Adoretus nitidus* Arr., *Gymnopleurus miliaris* F., and *Hypolithus* sp., at Mazar-i-Sharif; and *Adoretus nitidus*, *Anomala* sp., *Pæderus fuscipes* Curt., a large Melolonthid, *Polyphylla* sp., and a beautiful green Chrysomelid, *Chrysochares asiaticus* ab. *ignitus* Jacobs, at Doab-i-Mekhzarin.

The low-lying steppe in this region also form suitable breeding grounds for several species of locusts and grasshoppers. From Doshi to Pul-i-Khumri for over 35 miles, the valley seemed to be a breeding ground for *Calliptamus siculus* Burm., *Dociostaurus morrocanus* Thnb.(?), and *Oedipoda miniata* Pall. The Morroccan locust was found right up to Baghlan and even at Khanabad. Similar vast breeding areas of *Calliptamus siculus*, *C. turanicus* Tarb., and *C. italicus* L., with some specimens of *Oxya velox*

Thnb., *Calopternopsis* sp., *Gryllotalpa unispina* Sauss., and *Gryllus bimaculatus* Deg., were met with from Kundus to Hazrat Imam right up to the Russian boundary. The Calliphorid fly, *Sarcophaga hæmorrhoidalis* Fall., was found visiting ripe fruits at Mazar-i-Sharif.

(*iv*) *Hazarajat.*—Environs of Ghazni were thoroughly surveyed as a typical representative of this highland area. Of the various species of Aphididæ which were somewhat similar to those of Kabul plateau, *Aphis laburni* on willow was most common. The apple defoliator, *Hyponomeuta padellus* and the colding moth, *Carpocapsa pomonella*, although present were less serious. The hairy caterpillar, *Euproctis signata* Blanch., was found to have been most serious on almost all the deciduous fruit trees excepting mulberry, with the result that these orchards had not borne any fruit during the last two years. It is said to have come into sudden prominence with the historic severe winter of 1937-38, when probably its parasites got killed and the pest developed rapidly thereafter. At the time of our visit large number of caterpillars and pupæ were found parasitised by *Monodontomerus æreus* (?), and *Entedon* sp., adults of which were swarming in many orchards. Other noteworthy species collected were *Catocala afghana* Swinh., *Nomophila noctuella*, Schiff., *Utetheisa pulchella* Linn., *Laphygma exigua* (?), *Adoretus nitidus*, *Calosoma maderæ* F., and *Trigonotylus ruficornis* Geoffr.

(*v*) *South-Western Afghanistan.*—In this region Kandahar Province is the chief centre of agricultural and horticultural importance and it again lies at a low general altitude. Aphididæ were practically absent. The Tingid bug, *Monosteira unicostata* M. and R., was found actively breeding on willow and poplar, and *Stephanitis pyri* F., on apple. A few adults and numerous cast skins of the Cicada, *Psalmocharia rugipennis* Walk., were noticed on *Artemisia* growing wild near Kalat-i-Ghilzai. Some adults of *Rhaphigaster nebulosa* Poda, sucking apricot leaves and a predaceous bug *Sirthenea flavipes* Stal., were also collected.

Of the Lepidopterous species, most common were the codling moth caterpillars feeding in apple, apricot, plum and *bihi* fruits, and many hibernating and pupating under the bark of apple and apricot stem, a Eucosmid caterpillar boring into pomegranate fruit, and a Lymantrid hairy caterpillar and a Pyralid defoliating fig trees. Other noteworthy species collected were *Catocala afghana* Swinh., *Epicrocis ægnusalis* Wlk. (?), *Rhodometra sacraria* Linn., *Laphygma exigua* Hubn.(?), *Noctuella floralis* Hubn., *Plusia ni* Hubn., *Ommatopteryx ocellea* Haw., *Nomophila noctuella*, Schiff., *Utetheisa pulchella* Linn., and *Heodes phlæas* Linn.

Eggs and grubs of the Buprestid, *Sphenoptera lafertei*, were collected under the bark of peach stem from several orchards. The Coccinellids found common were *Adalia decempunctata* L., on poplar aphid, and

Synharmonia conglobata L., and *S. conglobata* ab. *orimnativa*, on apricot aphid. The Scarabæid, *Scarabæus sacer* L., was found in dung, the Chrysomelid, *Aulacophora foveicollis* (Lucas), on melon, the Cerambycid, *Stenolophus marginatus* Dej.(?), on soil, and *Aphodius lividus* Ol., at light.

The fruit-fly, *Myiopardalis pardalina*, was bred from maggots infesting melon. An adult of *Anacridium ægyptium* L., from poplar and various stages of *Chrotogonus* sp., damaging various nursery plants and vegetables were other important species collected.

VI. Acknowledgments

The author is thankful to the Government of India for giving him this opportunity of visiting and surveying the fauna of Afghanistan in a manner not otherwise possible for any individual or institution. He also desires to acknowledge with thanks the facilities given by the Afghan Government throughout the journey in that difficult country, the help and advice received from Mr. A. M. Mustafa and Dr. B. B. Mundkur, and the hard work done by the Insect Collector and Setter, Mr. W. Kerr. To Dr. H. S. Pruthi he is grateful for giving him facilities and advice in carrying out the survey, in examining the material and in writing up the account.

VII. Summary

As a member of the Agricultural Delegation, which the Government of India sent to Afghanistan in June 1939, the writer had the opportunity of visiting about one hundred localities during a journey of over 3000 miles and thus surveying the insect fauna of that interesting country. The outstanding feature of the insect fauna of the country is that it shows marked variations from place to place. This is mainly due to the diversities of climate and physical configuration of the different parts of the country. In this, the first contribution, a general account of the physical features, climate and rainfall of the country and their influence on the distribution of the most common or important insect species is given.

The country has been divided into five regions. (I) The Laghman and Jalalabad valleys were characterised by the presence of insects similar to those found in tropical and subtropical climate of north-west India, (II) The Kabul plateau was found to be particularly rich in Aphididæ and Coleoptera, particularly Chrysomelidæ, Coccinellidæ and Curculionidæ. Of the Lepidopterous species, the most common were *Hyponomeuta padellus* Linn., *Carpocapsa pomonella* Linn., *Pyrameis cardui* Linn., and *Coccœcia pomivora* Meyr. Some individuals of *Locusta migratoria* L., in the solitary phase were found in Sih Baba valley. (*iii*) In Afghan Turkistan with its lower altitude, Aphids were extremely rare. Of the coleoptera,

Meloide, Coccinellidæ and Scaræbidæ were common. The low-lying steppe formed suitable breeding grounds for various species of locusts, particularly *Calliptamus siculus* Burm., and *Dociostaurus morrocanus* Thnb. This is the chief cotton growing belt and it is noteworthy that this important crop was free from bollworm pests so serious in many other countries. (*iv*) The Central highlands of Hazarajat are of little agricultural importance. Several Aphids, *Hyponomeuta padellus*, *Carpocapsa pomonella*, and *Euproctis signata* Blanch., were among the most abundant species met with. (*v*) South western Afghanistan with Kandahar province as its chief horticultural area was characterised by the presence of *Sphenoptera laferti*, *Aulacophora foveicollis* (Lucas), *Myiopardalis pardalina* Bigot, and *Carpocapsa pomonella* in large numbers.

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THE PUPARIA OF SOME INDIAN TACHINIDÆ (DIPTERA). II.

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The present article deals with the puparia of twelve species of Tachinidæ that have been named by Dr. Baranoff since my first paper[1] went to press. It is possible that descriptions of one or two of Dr. Baranoff's species have not yet been published and should this be so, my descriptions of puparia are in no way intended to establish specific names.

49.* **Dolichocolon ater** Bar.

Dark red, moderately stout, more or less parallel-sided; surface smooth, some small separate patches above and below. Posterior spiracles borne on a strong rounded protuberance at ventral extremity, black, much longer than wide, somewhat compressed, distinctly divergent, apically rounded. Anus ventral, at the base of the rounded protuberance. Length about 5 mm.

Host: Caterpillars on *Carea arborea*. Palghar, Bombay.

This puparium with its elongate posterior spiracles borne together on a large ventral rounded tubercle is not like that in any other Indian species I have seen.

50. **Exorista grisellina** Bar.

Dark red; moderately elongate, surface smooth, with intersegmental asperities. Posterior spiracles black, subcircular, moderately large, separated by less than the width of one of them; each plate solid and slightly raised, with three nearly straight slits on obtuse ridges, the middle slit directed towards the submarginal button, the upper slit subvertical. Below the spiracles is a strong subcircular wart which is rather more protuberant than the spiracles themselves. Anal patch ventral, small, subcircular. Length about 6 mm.

Host: *Delias eucharis* Drury (Pieridae). Dehra Dun, U.P.

[1] Gardner, 1940, *Indian Forest Records, Ent.*, 6 (7): 227-351; 3 plates.

* The numbering is in continuation with the previous descriptions published in the above paper. The numbering of the figures, illustrating various species, is the same as in the text.

51. **Masicerella indistincta** Bar.

Castaneous, moderately elongate, rounded posteriorly; surface smooth, shining, with a few lines of distinct asperities along segmental sutures. Posterior spiracles on long axis, small, black, subcircular, separated by less than the width of one of them, very slightly raised above the surface, without ridges, with four slits of which three are sinuate and one usually nearly straight; button not on margin. There is no wart below the spiracles. Anus small, transverse, ventral. Length about 5 mm.

Host: Caterpillars on *Urena lobata*. Burma.

52. **Zenillia roseanella** Bar.

Dark testaceous; surface smooth and shining, with thin intersegmental rows of asperities; moderately stout. Posterior spiracles near long axis, small, subcircular, separated by less than the width of one of them; each plate with solid black base, slightly raised and with four short sigmoid slits; button submarginal. There is no wart below spiracles. Anus ventral, small, transverse. Length about 6 mm.

Hosts: *Hapalia machæralis* Wlk., *Dichocrocis* sp. (Pyralidæ). Burma; Madras.

53. **Argyrophylax nigritibialis** Bar.

Dark red, moderately stout, surface smooth and shining, with intersegmental lines of asperities. Posterior spiracles near long axis, small, subcircular, separated by less than the width of one of them; each with a solid somewhat raised black plate and with four short straight slits not on well marked ridges; button removed from margin. There is no medium wart. Anus small, ventral, transverse. Length about 4.5 mm.

Host: *Hapalia machæralis* Wlk. (Pyralidæ). Nilambur, Madras.

54. **Actia mallochiana** Bar.

Dark red; dorsal surface rather strongly convex; surface smooth with intersegmental rings of asperities. Posterior spiracles small, on long axis, slightly higher than wide, separated by less than the width of one of them; each with three straight slits on rounded ridges, the middle slit ending below the button which is marginal; no well defined basal plate. Wart absent. Anus transverse, ventral. Length about 3.2 mm.

Host: Lepidopterous larvæ. Dehra Dun.

55. **Actia aberrans** Mall.

Dark reddish, moderately stout ; surface smooth, with intersegmental rings of distinct asperities. Posterior spiracles circular, near long axis, separated by less than the width of one of them, very slightly raised above the surface ; each plate with three straight or slightly sinuate slits on very weak ridges, the slits horizontal or nearly so ; button not marginal. Below the spiracles is a distinct oval wart. Anus transverse, ventral and well behind posterior extremity of puparium. Length about 4 mm.

Host : *Hapalia machaeralis* Wlk. (Pyralidæ). Burma.

56. **Winthemia diversa** Mall.

Very dark red, rather stout, bluntly rounded posteriorly ; surface rather strongly transversely striate, with very distinct rings of asperities. Posterior spiracles moderate, subcircular, each with three straight slits borne on rather strong obtuse ridges ; the middle slit directed towards the button which is removed from the margin ; the upper slit subvertical. A median transverse wart distinct. Anus ventral. Length about 8.5 mm.

Host : *Prodenia litura* F. (Noctuidæ). Tittimatti, Coorg.

57. **Euhapalivora indica** Bar.

Red, moderately stout ; surface smooth, shining, with thin lines of intersegmental asperities. Posterior spiracles well above long axis, broadly oval, small, separated by less than the width of one of them ; each plate with solid, slightly raised base and with three sigmoid slits ; button near margin. There is no median wart. Anus ventral, transverse. Length about 6 mm.

Hosts : *Hapalia machaeralis* Wlk. and *Pygospila tyres* Cram. (Pyralidæ). Palghar, Bombay.

58. **Thelaira nigripes** F.

Almost black ; surface finely striate ; moderately stout. Posterior spiracles on long axis, very large, flat with smooth surface partially divided by sulci into three parts, without ridges, the slits extremely fine and irregularly serpentine ; the plates distinctly higher than wide, more or less oval, narrowly separated ; button on interior margin, circular ; between the plates, near the middle, is a small fusiform flat area. There is no medium wart below spiracles. Anus ventral. Length about 7 mm.

Hosts : *Amsacta lactinea* Cram. (Arctiidæ) ; Lasiocampid larvæ. Dehra Dun, U. P. ; Nilambur, Madras.

59. **Nemorilla floralis** Fall.

Dark red ; rather elongate ; surface smooth and shining with thin lines of intersegmental asperities. Posterior spiracles a little above long axis, almost circular, separated by less than the width of one of them ; each plate thickened and quite distinctly raised above the surface, with three straight slits on obscure rather flattened ridges ; the upper slit oblique, the middle one directed below the button, the lowest slit nearly horizontal ; button submarginal. There is no median wart. Anus ventral. Length about 5.5.

Host : *Hapalia machaeralis* Wlk. (Pyralidæ). Coorg.

60. **Phania indica** Walker

Testaceous brown, very stout, about three fourths as wide as long ; surface glabrous, smooth, the segmental divisions slightly indented. Posterior spiracles on long axis and at the slightly narrowed posterior extremity ; large, higher than wide, the inner margins straight, parallel and narrowly separated, each plate almost semicircular, slightly protuberant, the surface convex smooth with very fine serpentine slits ; each plate divided into three or four parts by fine sulci ; the button depressed, nearer inner than outer margin. Immediately below the spiracles is a narrow transverse dull strip, apparently containing the anal orifice. Length about 5 mm., width about 3.7. mm.

Host : *Sylepta* sp. (Pyralidæ). Dehra Dun, U.P.

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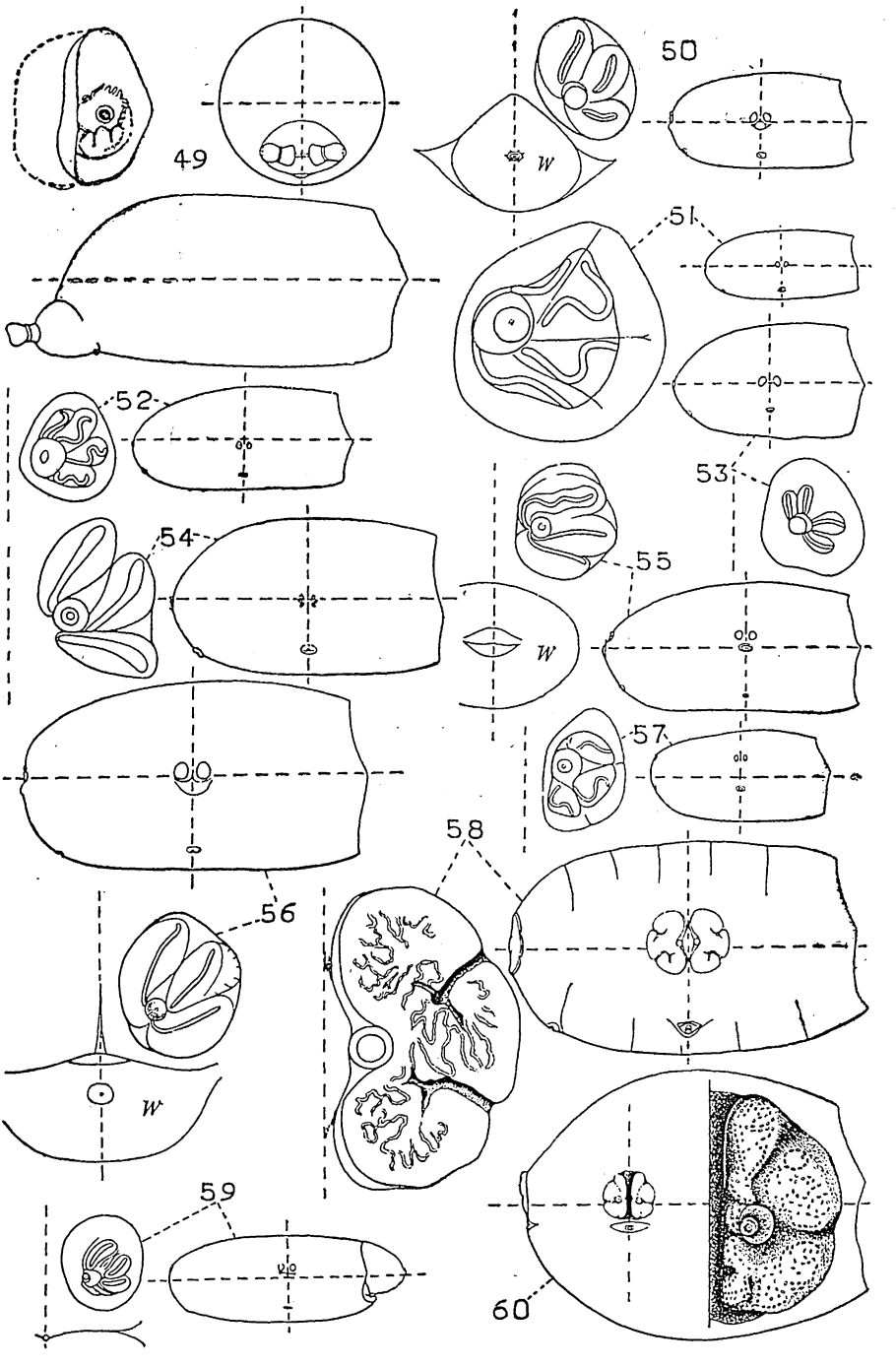
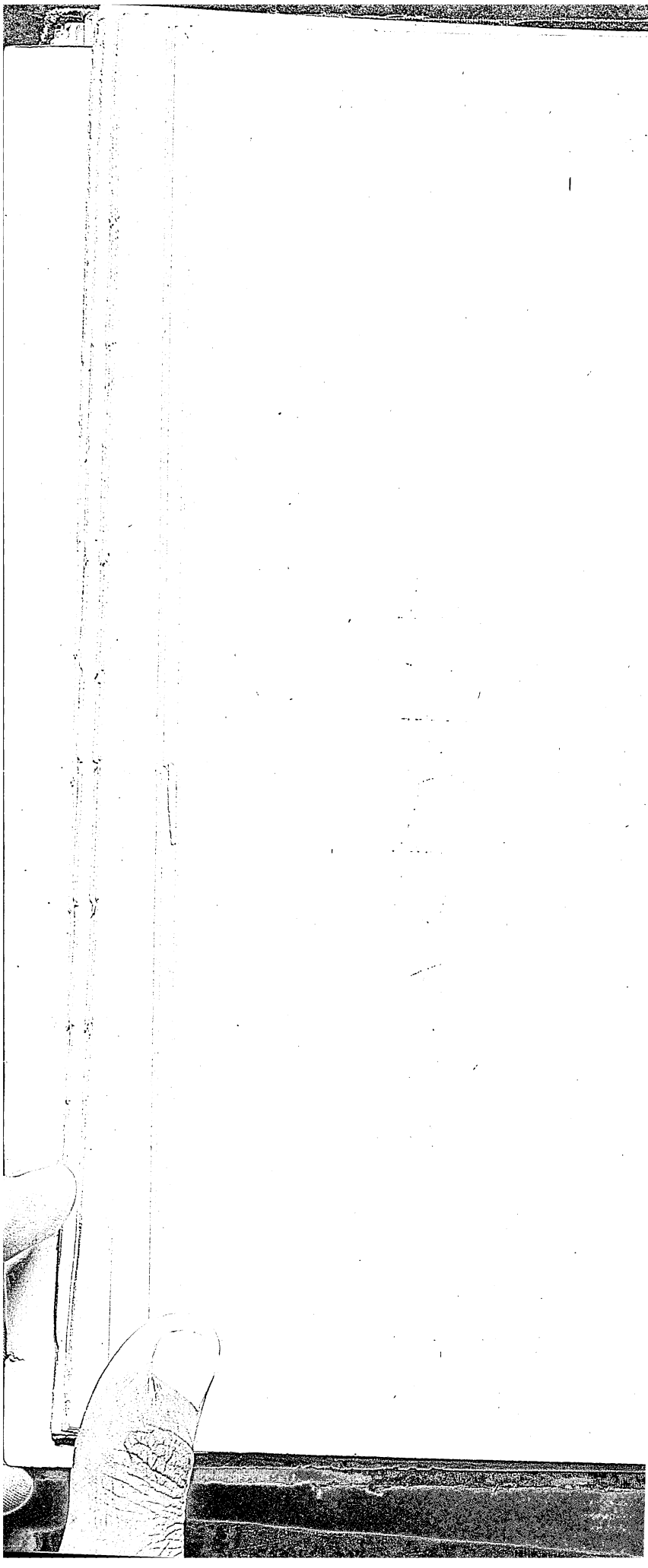


Fig. 49. *Dolichocolon ater* Bar. 50. *Exorista grisellina* Bar. 51. *Masicerella indistincta* Bar. 52. *Zenilla roseanella* Bar. 53. *Argyrophylax nigritibialis* Bar. 54. *Actia mallochiana* Bar. 55. *Actia aberrans* Mall. 56. *Winthemia diversa* Mall. 57. *Euhapalivora indica* Bar. 58. *Thelaira nigripes* F. 59. *Nemorilla floralis* Fall. 60. *Phania indica* Walker.

Figures not to same scale. Dotted lines indicate longitudinal and vertical axes. *w*=wart.



A NEW EUCOSMID MOTH ATTACHED TO *PALAS* (EUCOSMIDÆ, LEPIDOPTERA)

By T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.R.E.S., F.Z.S.

Acroclita cryptiolitha, sp. nov.

Male 12 mm. *Head* greyish-brown: face and frontal tuft blackish; scales rather erected on back of crown, forming slight tufts, with some black scales basally behind antenna. Antenna brown, obscurely ringed darker. Labial palpus: second segment brown, slightly upcurved, rather roughened with scales intermixed with blackish; third segment very short, blunt, blackish.

Thorax greyish-brown, bases of tegulæ with blackish spots (sometimes connected with blackish across foremargin of thorax, and sometimes central portion of thorax slightly irrorated with blackish).

Abdomen dark gray, posterior margins of segments slightly paler.

Legs greyish-brown, tarsi dotted fuscous above.

Forewing: costa strongly upcurved at base, then straight to apex, termen slightly incurved below apex to termination of vein 7, thence very gently incurved to rather rounded tornus, dorsum boldly excurved near base, then slightly incurved to tornus, so that greatest breadth is at $\frac{1}{4}$: greyish-brown irrorated with fuscous; along costa a series of about ten tolerably equidistant, short, outwardly-oblique, ill-defined blotches, of which the fifth (slightly before $\frac{1}{2}$) and last (immediately before apex) are rather larger, and those between these two larger blotches are shorter than those on the basal half of the wing; the interspaces between these costal blotches rather paler than ground-colour, the outermost interspace larger and more triangular; from base of costa a moderately broad rather irregular outwardly-curved bar, enclosing some red-brown scales on its lower half, running to dorsum and emitting a narrow blackish recurved mark from above middle of its outer margin (this mark sometimes continued as a blackish suffusion along fold); an ill-defined black longitudinal bar between $\frac{1}{2}$ and $\frac{3}{4}$, rather nearer costa than dorsum; the area above and beneath this bar intermixed with some red-brown scales showing coppery reflexions in certain lights; the inner and outer edges of ocellus faintly indicated by blue-leaden scales, and more strongly expressed blue-leaden scales extending in a broad line before termen from tornus to incurve beneath apex (and in some specimens this line of leaden scales and outer edge of ocellus extended rather faintly obliquely upwards and inwards to costa); terminations of veins 3-7 indicated in black; (dorsal area below fold and between base and inner edge of ocellus marked with whitish and ochreous

scaling in one male Cotype, in which also the costal blotch just before $\frac{1}{2}$ is continued across the wing to fold as a narrow black line, which is preceded by a rather faint transverse line of blue-leaden scales); cilia on termen fuscous, finely intermixed with greyish, darker at bases.

Hindwing greyish, finely irrorated fuscous, especially on terminal area and around apex, the darker irroration composed of transverse rows of dark scales, the veins also irrorated dark fuscous; when examined obliquely, the basal area (in female the pectinal area) shows a brilliant blue iridescence (hence the name bestowed on this species, KRYPTOS, hidden+ION violet+LITHOS, jewel): cilia greyish, narrowly paler along bases, then fuscous for about $\frac{1}{3}$ of length, followed by a narrow paler-grey parting-line, those from opposite vein 5 to around apex coarser and fuscous, dotted grey. Underside of both wings thickly covered with greyish scales on costal region above cell.

Type ♂, Namkum (Ranchi District), labelled 4.iv.1939, ex *palas* (*Butea frondosa*) (*P.M. Glover*); *Cotypes*, 2 ♂ 2 ♀, also from Namkum ex *palas*, 28.iii—4-iv.1939. This short series shows considerable variation, no two specimens being exactly alike. The description is made from the *type*, those portions within brackets indicating the more salient differences shown by other individuals of this series. The *type* and two *cotypes* have been placed in the Imperial Pusa Collection, Imperial Agricultural Research Institute, New Delhi, one ♂ *cotype* is in my Collection and another *cotype* in the Collection of the Indian Lac Research Institute, Namkum, Ranchi.

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A NEW SPECIES OF CHRYSOMELIDÆ FROM SOUTH INDIA

By G. D. BHASIN, B.SC.,
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(Communicated by Dr. N. C. Chatterjee)

Subfamily CHLAMYDINÆ

Exema salemensis, sp. nov.

Black; labrum, antennæ, basal half to two-thirds of the anterior and middle femora fulvous, the last two tarsal joints of all legs dark fulvous. Head and anterior half of pronotum covered with long golden-yellow pubescense. Elytra coarsely punctured, with a complicated pattern of tubercles.

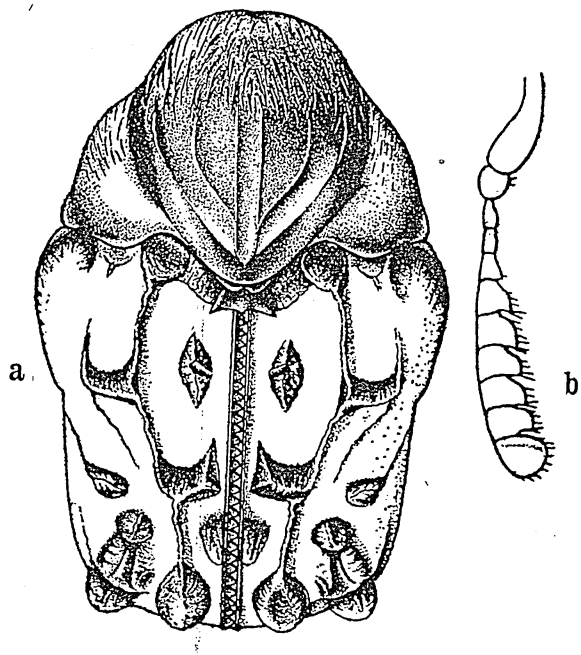

FIG. I. *Exema salemensis* sp. nov. **a,** dorsal view of the beetle; **b,** antenna.

Head flat, covered with long golden yellow pubescense; labrum fulvous; antennæ fulvous, short, extending to about the middle of the lateral margins of the thorax, basal joint subcylindrically elongate, second stout and globular, third and fourth slender and subequal, fifth equal to

fourth, slightly widened apically, remaining segments transverse. Pronotum with about anterior half covered, like the head, with long golden yellow pubescense, which extends back rather thinly along the sides to the posterior margin, middle portion raised into a rounded elevation, bounded laterally by shallow oblique grooves, with four longitudinal ridges, the middle pair parallel, not extending anteriorly beyond the middle and not reaching the hind margin, the external pair more distinct, a little longer, diverging anteriorly, and joining posteriorly the middle pair at or near the posterior end, the entire surface evenly, closely and strongly punctate, interstices raised. Scutellum transverse, hind angles produced. Elytra broadest at the base, constricted behind the shoulders, more deeply and coarsely punctured than the pronotum, each with the following tubercles :—A large median tubercle on the basal margin, one on the shoulder, two before the middle, the outer in the shape of a transverse ridge, two median and five behind the middle (a minute one adjoining the suture, another lateral to it, placed behind the middle of the median pair, one just behind the last, one at the top of the posterior declivity towards the suture and one nearer the outer lateral angle). Some of these tubercles connected by indistinct ridges ; suture denticulate. Pygidium with a distinct median ridge and a longitudinally raised area on either side. Underside black, closely and evenly punctured. Legs with the hind femora rugosely punctate. Length, 2 mm.

Described from five specimens collected during February and March, 1939 by the Research Ranger at Denkanikota, North Salem, Madras. *Type* in the British Museum ; *paratypes* in the Forest Research Institute, Dehra Dun, U.P.

Easily distinguished from the other described species of *Exema* by the presence of golden-yellow pubescense on the head and pronotum.

(*Received for publication on* 10. ix. 40.)

OBSERVATIONS ON THE BIOLOGY OF THE DESERT LOCUST (*SCHISTOCERCA GREGARIA* FORSK.) IN SIND-RAJPUTANA DESERT AREA

I. THE PREFERRED FOOD PLANTS OF THE LOCUST.

By D. R. BHATIA, M. SC.,

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INTRODUCTION

A thorough knowledge of the plants normally eaten by the desert locust is of special importance in enabling one to predict the possibilities of locust development in any particular tract. Some observations on the plants preferred and avoided by the desert locust in its swarming stage in Sind were recorded by Mann and Burns (1927). Kunckel d' Herculais (as cited by Uvarov, 1928) has given a list of wild plants fed upon or avoided by this species in Algeria. The object of this paper is to record some observations, made by the writer in the course of the past six years, on the food plants of the solitary phase hoppers of the desert locust in the Sind-Rajputana desert.

Observations made in the field were checked by experiments performed at Chachro (Sind). Subsequently, some trials in regard to the repellent effect of the extracts of *neem* (*Azadirachta indica*) and *ak* (*Calotropis gigantea*) leaves on the hoppers were also made.

DESERT PLANTS LIKED AND DISLIKED BY THE DESERT LOCUST

To test their likes and dislikes, about ten hoppers of I-V stage were confined in a cage, $1.5' \times 1.5' \times 1.5'$, and fresh leaves of plants to be tested were offered as food. In case any plant was refused, the experiment was repeated several times. Whenever prolonged experiments were to be made, fresh leaves were provided before the previous set of leaves began to get dry.

(*a*) *Plants definitely refused*

Ak and *neem* were the only plants the leaves of which were not eaten by the hoppers even at the end of twenty-four hours' starvation. Ovules of *ak* flowers were, however, eaten. Adults also did not eat the leaves of these plants, but *neem* leaves were once slightly nibbled at after about ten hours.

(*b*) *Plants sparingly eaten*

Bordi (*Zizyphus rotundifolia*), *bavuri* (*Acacia jacquemontii*), *murant* (*Panicum turgidum*), *jhal or khabar* (*Salvadora persica*), *arni* (*Clerodendron phlomoides*), *phog* (*Calligonum polygonoides*), *chibar* (*Cucumis trigona*), *dudeli* (*Euphorbia granulata*), and *tursan* (*Citrullus colocynthis*) were only slightly eaten. Of these *phog* was eaten after starvation for three hours, *dudeli* and *chibar* after four hours and *tursan* only after twenty hours.

In one of the experiments *neem* and *ak* leaves had been offered, but were refused for twenty-four hours. *Tursan*, which is generally not liked, was introduced in this cage and was quite readily accepted presumably under the stress of starvation.

(*c*) *Plants consumed without hesitation*

(i) Cultivated plants.—*Bajri* (*Pennisetum typhoideum*), *kaling* (*Citrullus vulgaris*), *til* (*Sesamum indicum*), *moth* (*Phaseolus aconitifolius*) and *guar* (*Cyamopsis psoralioides*).

(ii) Wild plants.—*Wekra* or *bekker* (*Indigofera cordifolia*), *vishani* or *maso* (*Tephrosia hookeriana*), *kanti* (*Tribulus terrestris*), *bharut* (*Cenchrus catharticus*), *bagra* (*Gynandropsis pentaphylla*), *santa* (*Trianthema pentandra*), *gamol* (*Panicum antidotale*), *siwan* (*Elionurus hirsutus*), *booh* (*Aerua javanica*), *gandhil* (*Dactyloctenium scindicum*), *bhengri* (*Blepharis sindica*), *kuri* (*Brachiaria* sp.) and *thohar* (*Euphorbia neriifolia*).

PLANT PREFERENCE EXPERIMENTS

In these experiments first and fifth instar hoppers were introduced into a cage containing fresh leaves of the various food plants referred to above. After about five hours (during which the plants were shuffled a number of times to eliminate chance preferences), the leaves were examined to find out the extent to which each plant had been eaten. The following inferences were drawn :—

(*a*) *Bajri*, *til*, *wekra*, *vishani* and *kanti* are preferred to others.

(*b*) Semi-dry or mature samples of even those plants which are usually preferred, may be given up in favour of fresh specimens of certain other plants not much liked ordinarily. For instance, if semi-dry *bajri*, *wekra* or *vishani* are offered alone with fresh *booh* leaves, the latter are preferred, whereas if all the plants were offered in a fresh state, *booh* would take a lower place in the preference list.

OBSERVATIONS IN NATURE

In the course of locust surveys in the Sind-Rajputana desert, it was noted that :—

(1) Certain species of plants were liked best. This preference, it is suggested, may lead to concentrations of hoppers and adults, when the distribution of the preferred species is localized and thus cause the transformation of phase.

(2) Whenever the most preferred plants were not available, the hoppers were found feeding on other plants.

(3) In case the most favourite plants were in a semi-dry or mature condition, succulent plants of species, generally not preferred, were chosen.

The following instances may be given in support of the above observations :—

(*a*) *Locality.*—Nokh (Jaisalmer State).

Vegetation in breeding areas.—*Booh, chag* (*Crotalaria burhia*) and *gandhil* were abundant. Other plants available were *murant, siwan, lana* (*Haloxylon salicornicum*), *khip* (*Leptadenia spartium*), *bordi, bharut, lampdi* (*Aristida* sp.), *ak, tursan* and a slight growth here and there of *wekra* and *kanti.*

It was found that on account of the absence of a good growth of *wekra, vishani, kanti,* etc. the hoppers were found mostly among *booh.*

Year	Total number of hoppers	Plants on which noted	
1936	236	*booh*	231
		wekra	4
		kanti	1
1937	124	*booh*	95
		bajri	28
		wekra	1

(*b*) *Locality.*—Areas from Nokh to Girasar and Srikolayatji (Jaisalmer and Bikaner States).

Vegetation—*Wekra* and *gandhil* predominated ; *booh* and *kanti* were common. *Bharut, tursan* and *gandhil* were also present.

Hoppers were noted as under :—

Date	Total No.	Plant on which collected	Remarks
8. VIII. 1936	3	*kanti*	*kanti* in fresh condition
17. VIII. 1936	14	,,	
3. XI. 1936	8	*booh*	*kanti* in dry condition

(*d*) *Locality.*—Sadulpur (Bikaner State).

Vegetation.—*Maso* or *vishani* was most abundant, *booh, kamero, phog, bordi, bharut, luchabri* (*Cyperus arenarius*) *bajri, guar, chibar, moth* and *santa* were also present.

Hoppers were noted as under :—

Date	Total No.	Plant on which collected		Remarks
10-12. VIII. 1937	67	*maso* *booh* *bordi*	62 4 1	In addition, a number of hoppers were noted mostly on *maso*.
3. IX. 1937	1	*maso*	1	
7. X. 1937	1	*maso*	5	*maso* was dry and hard.

(*e*) *Locality.*—Sardarshahr—Sonpalsar area (Bikaner State).

Vegetation.—*Luchabri* was quite abundant. *Phog* and *bharut* were also present.

Hoppers were noted as under :—

Date	Total No.	Plants on which collected	Remarks
15. IX. 1936	4	*luchabri*	*luchabri* fresh.
7. XI. 1936	3	*booh*	*luchabri* dry and hard.

The observations under (*a*) and (*c*) above, show that *kanti, maso* and *luchabri* were selected when in a fresh state, but *booh* was preferred when they were no longer in a tender condition. *Booh*, being a deep rooted perennial, remained green much longer than the short-lived *luchabri, maso, kanti* and *wekra*.

It may be pointed out that the observations detailed above were taken on solitary phase specimens. After the development of gregarious instinct, the hoppers and adults seem to prefer high growing bushes like *kirrer* (*Capparis aphylla*) and *phog* for congregation at night or mid-day.

Repellent effect of *neem* and *ak* extracts

Volkonsky (1937) has shown that plants sprayed with the extracts of *neem* (*Melia azedarach*) were avoided. In this connection, a few preliminary observations were made by the writer, using the Indian species of *neem* (*Azadirachta indica*). *Bajri* and *kaling* leaves, wetted with *neem* extract, were provided to third, fourth, and fifth stage hoppers and adults (solitary and gregarious) of the desert locust. It was found that they tried to lick the treated leaves but promptly showed their dislike by shaking the head, rubbing the mandibles with their tarsi or rising on their legs. Observations were continued for twenty-four hours, but it was found that the treated leaves were not touched. As soon as untreated leaves were introduced, they were readily eaten. The problem is important from the point of view of saving valuable crops and garden plants, temporarily till control measures could be undertaken. Experiments with *ak* leaf extract were also tried but these appeared to show negative results, i.e., the extract did not make the plants unattractive to the locust.

Summary

1. *Schistocerca gregaria* Forsk. (phase solitary) feeds upon a number of wild plants and practically all the cultivated ones. The only plants which were not eaten were *neem* and *ak* (except the *ak* ovules). A list of plants avoided and eaten is given.

2. When a number of plants are available in fresh condition, certain plants are preferred to the others. This fact was noted in nature as well as under experimental conditions.

3. If the plants liked best are in a semi-dry condition they may be disearded in favour of fresh and succulent condition though ordinarily not much liked.

4. It is suggested that the preference shown for certain particular plants may lead to a concentration of hoppers (and probably of adults as well) when the distribution of the preferred plants is localized and may thus lead to phase transformation.

5. The repellent effect of sprays of *neem* and *ak* leaf extracts on locusts through their food plants is discussed.

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SOME OBSERVATIONS ON THE PERIODICITY OF LOCUST INVASIONS IN INDIA*

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INTRODUCTORY

Till the beginning of the nineteenth century, there are no definite records of the occurrence of locusts in India. Cotes (1891) has collected much of the available information from 1800 to 1869, after which fairly definite information is on record. The depredations of locusts during the last locust cycle (1926-31) led to the formation of a central locust bureau for locust intelligence, and to the initiation of investigations relating to the bionomics of the locust and to a search for its permanent breeding grounds in the Indian area.

AN EVENTFUL DECADE OF LOCUST RESEARCH

The outbreak of the desert locust (*Schistocerca gregaria* Forskal) of 1926-31 was by no means confined to India. It occurred simultaneously over large areas of south-western Asia and north and central Africa where similar schemes of investigation were instituted by the affected countries. In the African area, two other locusts—the tropical migratory locust (*Locusta migratoria migratorioides* Reiche & Frm.) and the red locust (*Nomadacris septemfasciata* Serv.) were also active, over very large areas, and consequently all these locusts were included in the schemes of research. These investigations stimulated work on other locusts not only in Asia and Africa but all over the world, and before long, workers felt the need for pooling knowledge thus gained independently in different countries, and for co-ordinating anti-locust measures in neighbouring countries. This led to the organization of a series of international locust conferences, in most of which a large number of countries participated : the first held at Rome in 1931, the second at Paris in 1932, the third at London in 1934, the fourth at Cairo in 1936 and the fifth at Brussells in 1938.

Among the many valuable resolutions passed during these conferences, were those dealing with the need of creating an organization for keeping a constant watch of the outbreak centres of various locusts and for promptly destroying the incipient swarms.

*Summary of the Presidential address delivered in the Entomological Section of the 28th Session of the Indian Science Congress held at Benares in January, 1941.

During a period of over ten years of investigations under the various schemes, the results obtained have greatly enriched our knowledge of the bionomics and habits of locusts in general, and of the ways in which they react to their environment. A large volume of evidence has accumulated on the subject of phase transformation in nature and much clarification has been obtained, as a result of ecological studies of the natural haunts of locusts, on the mode of origin of initial outbreaks. Detailed studies of swarm movements by the International Locust Centre at London have shown clearly how infestations had been developing in the affected areas from year to year, as an outstanding result of which may be mentioned the tracing of the great infestation of the tropical migratory locust covering over 10 million square miles of territory in the interior of Africa to an initial outbreak in 1926-27 in a comparatively small area in the region of the Niger Bend in French Sudan. Doubtless the whole infestation might have been nipped in the bud, if the initial swarms had been destroyed in time.

Much light has also been thrown on the activities of the solitary phase locusts, especially on their ability to make long distance migrations.

SOME OF THE IMPORTANT LOCUSTS OF THE WORLD

There are several species of locusts in the world, one of the most well-known of which is the migratory locust. This locust has developed into distinct races adapted to different types of countries. The European form is adapted to a cold climate, while the tropical migratory locust and the Malagasy locust are both suited to tropical conditions. The race found in the Philippines, China and Malay Archipelago is the East Asian form, while the one found in India is only exceptionally found in the gregarious condition.

The desert locust (*Schistocerca gregaria* Forsk.) is the most important in north Africa and south-west Asia. Other locusts of major status are the Bombay locust of Deccan, the red locust of Africa, the brown locust of South Africa, and the Moroccan and Italian locusts of the Mediterranean region. In South and Central America, and in Mexico, the South American locust (*Schistocerca paranensis* Burm.) is the dominant species.

Of these locusts, a good many have only one brood in the year, of which some, like the Bombay locust, the red locust and the South American locust, pass the greater part of the year in the adult stage, while in other species, such as the European migratory, the Moroccan and the Italian locusts, their eggs lie in a quiescent condition in the soil during the greater part of autumn and winter.

In all these cases, an increase in numbers is usually gradual and is dependent on a succession of favourable years. On the other hand, in the case of the desert locust, the tropical migratory locust, the brown locust, etc., the incubation period is short and normally two or more broods may be produced in a year. These species are most dangerous from the point of view of swarming, as they are able to pass through successive broods quickly, and, in case conditions are favourable for concentrated breeding, also to form incipient swarms rapidly.

Periodicity of locust outbreaks

All available information on the outbreaks of various locusts indicates that they are subject to considerable fluctuation in their numbers. Usually a series of years of heavy multiplication is followed by a period during which there is either a considerable decrease or a total disappearance of locusts.

Of the three species of locusts found in India, (1) the migratory locust very rarely forms swarms. An instance of heavy infestation in 1878 in the southern districts of India is on record, and recently an outbreak was reported in 1937 in the Rajputana-Kathiawar area. Except for these cases, it is usually found in the solitary phase. (2) The Bombay locust is endemic in the areas of the Western Ghats, and usually visits the neighbouring districts of Bombay, but in years of heavy infestation its swarms may invade districts of the United Provinces, Central India, the Central Provinces, Bihar, Hyderabad and northern Madras in addition to Bombay and Gujarat. Swarming is known to have occurred in 1835-45, 1864-66, 1878-84 and 1901-08. (3) The desert locust is *the locust par excellence* of India not only by the frequency of its visitations, but also by the extent and severity of its attacks. It is usually confined to the north-western parts of India, but at the height of its outbreaks its swarms may reach as far east as Assam and as far south as the north of Madras. As this locust has been under special investigation for nearly a decade, a fairly large amount of information has been collected in regard to its prevalence during the last century.

Periodicity of the desert locust in India

The destructive activities of swarms on record refer to the years :— 1803 ; 1810-13 ; 1821 ; 1826 ; 1833-34 ; & 1843-1845. The locust is known to have invaded Egypt in 1855, but there are no data for India at this time. Between 1860 and 1940, the following were the periods of locust invasion :— 1860-66 ; 1869-73 ; 1876-81 ; 1889-98 ; 1900-07 ; 1912-19 ; and 1926-31. There were thus locust cycles of 5 to 9 years each, with only short swarm-

free intervals 1 to 4 years each, except in three cases where they lasted 6, 7 and 8 years.

Till careful observations were made during the recent interval of 1932-39, there was little information as to what was happening to locusts during the period when swarms disappeared. These investigations have shown that locusts continue to exist during such periods in a non-gregarious form, distributed among the scrub vegetation of deserts in small numbers. The solitary locust reacts to changes in the weather in much the same way as the *gregaria* locust, and similarly has two broods in the year,—first in the spring months in the winter-rain areas, whence the new generation migrates at the beginning of summer into the summer-rain areas of the Rajputana desert, and breeds in the monsoon months. The new generation produced here migrates in autumn into the winter-rain areas, where breeding occurs in the spring of the following year. It was also observed that the solitary locusts are able to transform into the *gregaria* swarms whenever, in the wake of favourable rainfall, two consecutive broods are rapidly produced, and crowded breeding is brought about under conditions of concentration.

THE GENERAL COURSE OF A LOCUST CYCLE IN INDIA

Until the last locust cycle was carefully studied, only vague ideas were current as to the general course of swarm movements. Swarms were generally believed to enter India from the west and to pursue an easterly course in India, and after breeding for two or more consecutive seasons to die down within the Indian area. A close study of the data of the last outbreak shows that the activities of swarms may be classified under 1. over-wintering, 2. spring-breeding, and 3. summer-breeding.

(1) During the winter months, swarms become scattered among the vegetation in areas where they happen to be present at the onset of winter. Over-wintering usually occurs in the southern parts of Mekran, in Sind, Kachhi and south Punjab.

(2) When spring ushers in warm weather, they become active again and in case of good winter rainfall, begin to breed. In March, a general migration of swarms northwards into the mountain valleys of Baluchistan commences. The swarms gradually work their way up to Chagai, Sarawan, Quetta-Pishin and Zhob, and ultimately into the North-West Frontier Province *via* Afghanistan. Breeding occurs in these areas in April, May and June, and the new brood migrates eastwards into Punjab, Sind and Rajputana in May, June and July. Breeding also occurs in the Punjab in spring, whence the new brood moves eastwards into United Provinces, Bihar and Bengal in May-June.

(3) With the fall of monsoon showers, the swarms arriving from the western areas begin to breed in the Punjab, Sind, Rajputana and the United Provinces, wherever conditions are favourable. In case good rainfall is received in August-September, a second generation may be produced; otherwise, there is only one brood. With the withdrawal of the monsoon current, north-west India (especially the desert area) becomes an area of drought in September-October, and swarms produced here tend to leave the area either eastwards into the United Provinces, Bihar and Bengal, or southwards into Gujarat and Bombay or westwards into Sind, southern Punjab and Baluchistan, according to the prevailing winds. It is, however, only those that reach the Baluchistan and Iran areas that can breed again in spring; others die away ultimately.

Westward migration in autumn and winter plays an important part in carrying infestation to the year following, and when it does not occur, a perceptible decrease in the number of swarms usually follows. Again, the occurrence of drought either in the winter-rain areas in spring, or in the monsoon areas in summer may bring about a break in the locust cycle.

Reviewing the actual sequence of events in the 1926-31 cycle, it is seen that the absence of westward migration in the autumn of 1928 as well as a partial drought in the spring of 1929 in Mekran might have resulted in a break-down of the infestation, had it not been for the influx of swarms of Arabian and Persian origin in April-May and their breeding in parts of upper Baluchistan. The new generation migrated into Sind, the Punjab and Rajputana and gave rise to heavy multiplication in the monsoon period. Pronounced west-bound migration in autumn (1929) was followed by intense breeding in the Mekran area in the spring of 1930, which marked the peak of the outbreak. Failure of rain in August and September caused an early cessation of breeding in the desert, and most of the swarms migrated east and south. There was very little of westward movement in autumn (1930). Light breeding in spring 1931 and only partial multiplication in summer, followed by winter drought in Mekran in 1932, brought the cycle to a close.

Origin of new cycles of locust infestation

Observations made in the recent swarm-free interval (1932 to 1939) have shown that the following sequence of events generally marks the beginning of a new cycle. (1) Extensive breeding on the coastal areas of Mekran in the wake of heavy winter-spring rainfall; (2) migration of locusts from the coast into the interior in spring, and the occurrence of crowded egg-laying in or near patches of cultivation, leading to the production of incipient swarms; (3) migration of these in summer into Rajputana either as small loose swarms or as groups of individuals; and (4) their

extensive breeding in the desert, followed, in case of good and well distributed rainfall in July, August and September, by (5.) the intensive breeding of concentrations of locusts brought about by the dynamics of passing depressions, leading to the formation of large swarms.

Observations made in 1935 showed that large outbreak centres were produced in late spring in the hinterland of Mekran and that the new brood migrated in July into the desert area, where, however, owing to deficient rainfall in August, swarm production did not occur.

In 1926, on the other hand, owing to well-distributed rainfall in the monsoon months, heavy multiplication occurred in the desert, especially in the south, and resulted in the production of large swarms, which brought the 1926-31 cycle into existence.

In the case of the present outbreak (1940), multiplication commenced as early as last spring (1939) in Mekran in the wake of very favourable winter rainfall, but owing to the initial population being low, the increase in numbers was, apparently, not noteworthy, and as the monsoon in the desert areas was almost a failure, the monsoon brood was also poor. The winter-spring rainfall of 1940 in Mekran was moderate and so far as observed did not result in any remarkable breeding. The initial numbers of locusts found in summer in the desert were fairly good. It is presumed that they became concentrated in the patchy vegetation caused by the previous year's drought. Crowded breeding ensued especially after the heavy showers of August and caused the re-appearance of swarms after about 8 years.

The infestation of the 1912-19 cycle would appear to have come into existence under meteorological conditions more or less similar to the present outbreak. There was heavy rainfall in the spring of 1911, followed by a severe summer drought in the desert. The winter-spring rainfall of 1912 was normal, but there was fairly high monsoon rainfall in the desert, and swarms emerged in September-October in the south of the desert.

Heavy initial multiplication in the Rajputana desert in the years 1869 and 1900 were associated with severe summer drought in 1868 and 1899, and it is possible that an early patchiness of vegetation in the Rajputana desert in a year following a severe summer drought may bring about the formation of initial concentrations of locusts and thus to the production of swarms.

IMPORTANCE OF CHECKING THE INITIAL OUTBREAKS

At the Fifth International Locust Conference held at Brussells in 1938, stress was laid on the importance of (1) keeping under surveillance the areas known to be responsible for starting fresh outbreaks of locusts

and (2) of controlling the incipient outbreaks before they get out of control. In India such danger points lie in British and Iranian Mekran in regard to spring breeding, and in the Sind-Rajputana desert areas in respect of summer breeding. At present, however, no co-operation has yet been secured between Iran and India in regard to the watching of the outbreak areas.

Sunspots and locust cycles

Various authors, such as Swinton, Criddle, Uichanco and Richmond have traced the fluctuation in the numbers of locusts and grasshoppers to variations in the numbers of sunspots and have found an inverse correlation between them. The multiplication of locusts and grasshoppers is apparently highest when the sunspots are at the minimum.

A study of the available locust data in India since 1860 with reference to sunspot activity has indicated the existence of a similar inverse correlation between sunspots and the locust infestations.

Need of further research on locusts in India

Reviewing the achievements to the credit of locust investigations carried out in India during the last decade, it is seen that a decidedly large advance has been made in regard to our knowledge of (1) the bionomics of the locust, (2) the nature of its habitat and the details of its life-economy, and (3) the conditions under which new outbreaks may be brought into existence.

The practical aspect of the knowledge obtained lies in the fact that the locust is a harmless insect, until it begins to breed under crowded conditions, and that it is possible to check future infestations if the initial outbreaks are detected and checked in time. To achieve this object, however, it is necessary that the organization designed to undertake this work should be equipped with adequate staff and funds, since all expense incurred by the Government would after all, be a sort of crop insurance for the Indian ryot.

Much remains to be known of the ecology of the Bombay locust and the Indian migratory locust, and also of the conditions under which certain very injurious grasshoppers of India, such as the Deccan grasshopper, multiply in numbers in certain years.

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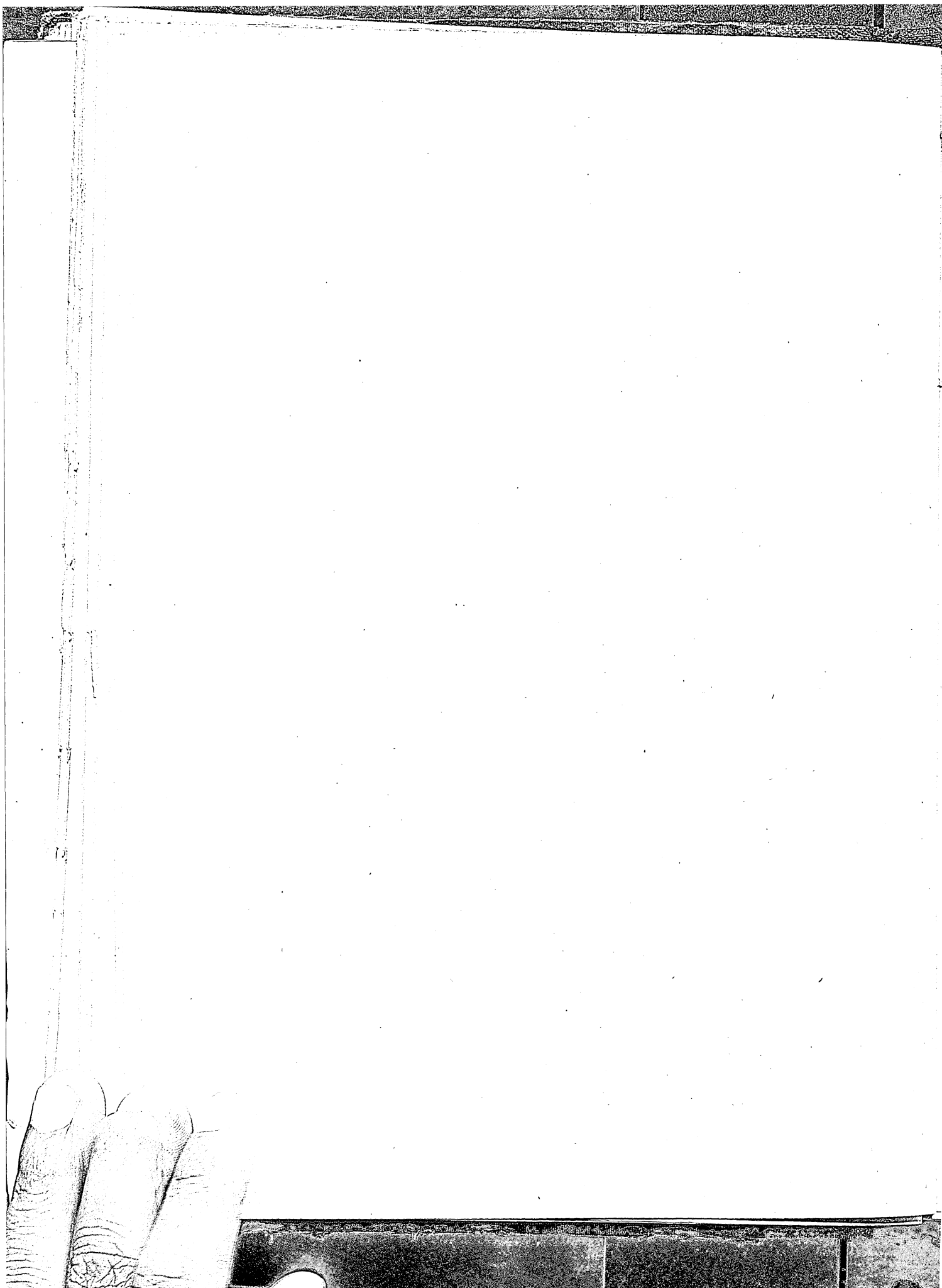

BIOLOGY OF THE MITE, *PARATETRANYCHUS INDICUS* HIRST, A PEST OF SUGARCANE IN THE PUNJAB*

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CONTENTS

I. INTRODUCTION

Paratetranychus indicus—a serious pest of sugarcane—was first described by Hirst (1923) as a new species from the material collected by Mr. Y. Ramachandra Rao from *cholam* (*Andropogon sorghum*) at Coimbatore. The exact year when it was first discovered in the Punjab is not known but the work on its biology † was taken up in 1936 at the suggestion of Mr. M. Afzal Husain, then Entomologist to Government, Punjab. The results are presented in this paper.

II. DISTRIBUTION AND FOOD-PLANTS

Paratetranychus indicus Hirst is a widely distributed species in India. Cherian (1933) has given its distribution in South India. We have identified it from collections made at Benares, Ranchi, Delhi and Meerut. In the Punjab it has been collected from the following localities :

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* This paper was read at the 27th Session of the Indian Science Congress, held at Madras in January, 1939.

† The apparatus evolved by H. H. Storey (*Ann. app. Biol.*, 15 : 1-25, 1928.) for the study of insect vectors of plant viruses was, after certain modifications, used in these studies.

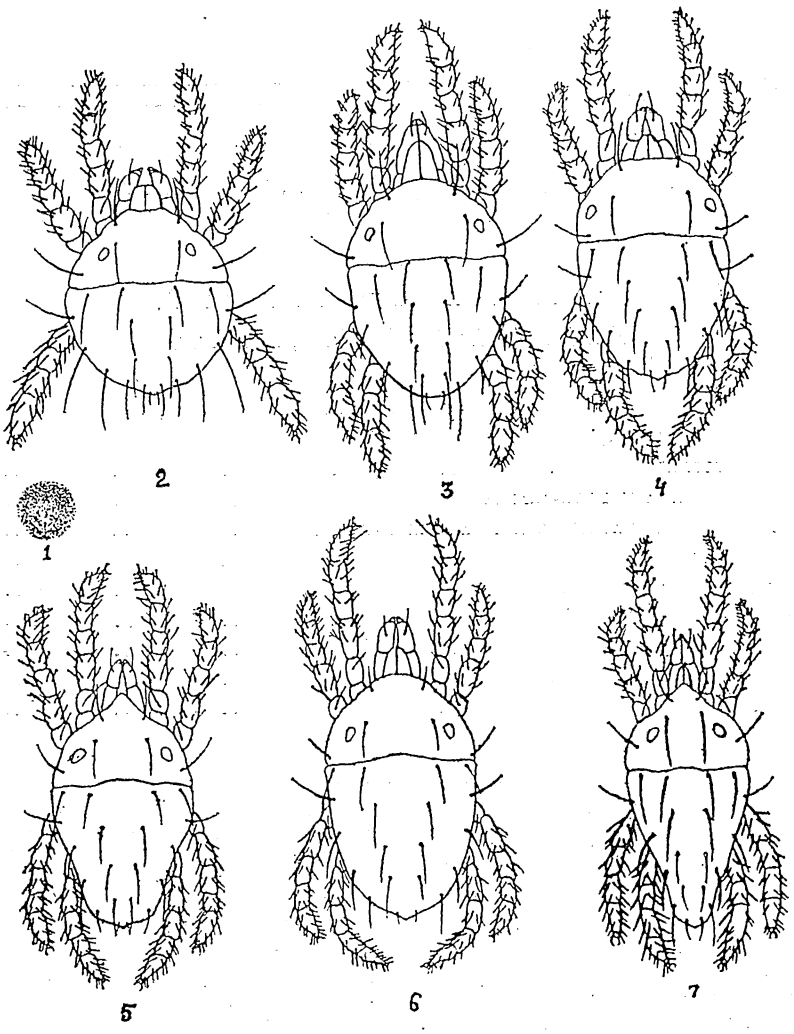

Fig. 1. Egg × 72
Fig. 2. Larva × 141
Flg. 3. Female protonymph × 117
Fig. 4. Female deutonymph × 88
Fig. 5. Male protonymph × 127
Fig. 6. Adult female × 69
Fig. 7. Adult male × 83

Campbellpur, Gurdaspur, Jullundur, Karnal, Lyallpur, Montgomery, Multan, Okara, Sargodha, Shahbazpur and Tanda (District Hoshiarpur), Sheikhupura and Sialkot.

In Southern and other parts of India it infests sugarcane (*Saccharum officinarum*), *cholam* (*Andropogon sorghum*) and two grasses, *Panicum javanicum* and *P. distachyum*, but in the Punjab it feeds upon sugarcane, *chari* (*Sorghum vulgare*) and *buru* (*Sorghum halepense*).

III. Description of various stages and life history

Egg (Fig. 1).—Spherical, 0.115 mm. in diameter. Dirty-white when freshly laid, changing to brownish later on, and becoming transparent along sides with red eye-spots becoming visible before hatching.

Larva (Fig. 2).—Length 0.147-0.210 mm., width 0.140-0.165 mm. Almost spherical in outline and light amber in colour at hatching, becoming elongated and developing a greenish tinge and dark specks on the dorsum later on. Dorsum with 13 pairs of hairs arranged as shown in the figure. Collar trachea generally ending in a single cell (Fig. 8). Palps with a hair and a bristle located between claw and dorsal finger, cone and dorsal finger equal in length and with two sensillæ between them, sensilla next to cone being long and stout (Fig. 9). Legs three pairs, first pair longest,

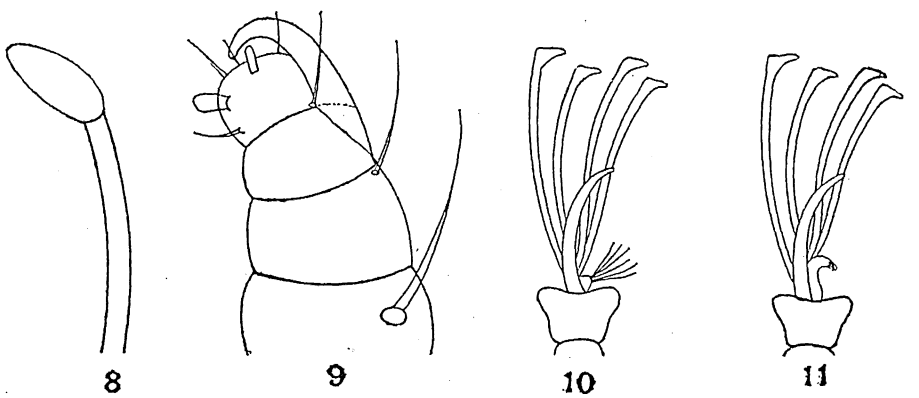

Fig. 8. Collar trachea of larva
Fig. 9. Palp of larva
Fig. 10. Claw of leg of female larva
Fig. 11. Claw of first leg of male larva

second and third pairs equal but shorter than the first. Claws of all legs in female larvæ similar and equal in length with protuberances near their bases bearing six bristles (Fig. 10), but those of first and second pairs of legs in the male larvæ with the dorsal portion formed into a

curved spur and the ventral portion formed into a hook which terminates in teeth (Fig. 11).

Protonymph (Figs. 3 & 5).—Body oblong and deep amber in colour on emergence, changing to greenish later on. Legs four pairs, first pair longest, fourth pair shorter than the first but longer than the second and third which are equal.

Male and female protonymphs distinguishable : male protonymph (Fig. 5) 0.214 - 0.241 mm. long and 0.165 - 0.178 mm. broad and more or less wedge-shaped ; female protonymph (Fig. 3) 0.220 - 0.268 mm. long and 0.165 - 0.183 mm. broad and is more or less rounded posteriorly.

Deutonymph (Fig. 4).—Greyish-green in colour on emergence but becoming dark green later on.

Male and female deutonymphs distinguishable : male deutonymph 0.236 - 0.294 mm. long and 0.183 - 0.196 mm. broad, without blotches on the dorsum and with the caudal extremity more narrowly rounded ; female deutonymph (Fig. 4) 0.281 - 0.343 mm. long and 0.200 - 0.247 mm. broad, with large blotches on the dorsum and with the caudal extremity rounded.

Adult (Figs. 6 & 7).—First described by Hirst in 1923, we have redescribed it in detail elsewhere (Rahman and Sapra, 1940).

Longevity of adult.—The adults live for 12½-17 days in April-September and 22-49 days during March and October-December.

Copulation.—Male usually emerges a little earlier than the female. It wanders about on the leaf and on coming across a quiescent female deutonymph, it places its anterior pairs of legs on it and waits. When the nymph starts moulting it becomes excited, rubs its anterior legs and palpi on the caudal extremity of the nymph and occasionally lifts its abdomen. These pranks hasten the process of moulting. Copulation usually takes place immediately on emergence of the female ; rarely however, it may take place as soon as the female has protruded the tip of its abdomen through the dorsal fracture.

For copulation, the male slips underneath the female from behind. It clasps her abdomen on either side of the apex with its anterior pairs of legs by bending them at the femoro-patellar joint ; this position of the legs also raises the female abdomen slightly, the male curves its abdomen upwards and forwards till its tip meets that of the female abdomen, when copulation begins.

Mating may last from 40 seconds to 2 minutes, but if disturbed the mating couples separate immediately.

Both polygamy and polyandry are common in this mite.

Preoviposition period.—The duration of the preoviposition period depends upon the season : during April-September it lasts for 1-2 days, with an average of $1\frac{1}{2}$ days, while during March-October it lasts for 3-5 days, with an average of $3\frac{1}{2}$ days.

Oviposition.—The mite begins to lay eggs towards the end of February. The succeeding generations continue to oviposit upto November. The most active period for egg laying, however, is from March to October. The oviposition period lasts for $9\frac{1}{2}$-$14\frac{1}{2}$ days, with an average of 11.8 days, during April-September, but during March and October-December it occupies 17-39 days, with an average of 23.1 days. During winter (mid December to mid February) fewest eggs are laid.

A female lays 1-7 eggs daily, the total number of eggs laid by her in her life-time ranges from 35-69, with an average of 53 (Table I).

TABLE I. *Oviposition records of* P. indicus Hirst

Month	Number of observations	Number of eggs laid daily			Total number of eggs laid		
		Min.	Max.	Av.	Min.	Max.	Av.
March	10	1	4	2.6	35	61	48.8
April	12	2	7	4.0	35	63	50.7
May	15	3	7	3.9	40	63	52.3
June	14	3	7	5.3	42	64	55.9
July	14	2	7	3.9	40	60	51.7
August	15	3	7	3.9	41	68	51.7
September	15	3	7	4.4	41	67	54.8
October	12	2	4	2.9	43	69	56.3
November	10	1	3	1.6	52	56	55.4

Postoviposition period.—The females die immediately after laying the last egg during April-May, but their postoviposition life is 1-3 days in June-September and 2-6 days in October-November.

Longevity of male.—The males die within 96 hours after mating, but if they remain unmated, they may live for 8-12 days during March-September and 12-20 days during October-November.

Hatching.—The chorion splits on one side along the circumference in the vertical plane. The larva widens this opening by pushing the two sides apart with its legs and comes out, leaving the egg-shell intact.

Duration of the egg-stage varies with the season : eggs laid in April-September hatch out in $2\frac{1}{2}$-3 days, while those laid in March and October-December, and January take 5-13 and 29 days respectively to hatch (Table II).

TABLE II. *Egg-stage of* P. indicus *Hirst*

Eggs laid on	Eggs hatched on	Duration (in days) of egg stage.
9.III (M)	18.III(M)	9
21.IV (M)	24.IV(M)	3
30.V(M)	1.VI.(E)	$2\frac{1}{2}$
15.VI(M)	18.VI(E)	$3\frac{1}{2}$
22.VII(E)	25.VII(E)	3
13.IX(E)	16.IX(E)	3
8.X(E)	13.X(E)	5
9.XI(M)	17.XI (M)	8
4.XII(M)	17.XII(M)	13
11.I(M)	9.11(M)	29

Instars.—There are three larval instars*, the first instar is known as the larva, the second as the protonymph and the third as the deutonymph. Each instar covers an active feeding period followed by a period of quiescence, the two periods being of equal duration.

At the termination of the period of quiescence of an instar, the young one becomes pearly-white, the skin rupturing transversely soon after along the dorsal furrow. This fracture gradually widens by the muscular movements of the mite. The posterior extremity and the posterior pairs of legs of the young one are thrust out of the breach thus formed, the mite " rearing back " draws the rest of its body out of the exuvia which is left on the leaf in tact. Rarely, however, the anterior extremity of the body is " born first " and, when this happens, the posterior portion of the exuvia remains attached to the tip of the abdomen for a long time after moulting.

The duration of the immature stages varies with the season : they separately occupy $1\frac{1}{2}$-3, $4\frac{1}{2}$-8 and 13-19 days in male and 3-5, 6-11 and 16-24 days in female, during April-September, March and October-November, and December-February respectively (Table III).

* During the course of these investigations it was observed that, particularly in summer, some of the male larvæ had only two instars.

TABLE III. *Duration of immature stages of* P. indicus *Hirst*

Eggs hatched on	Adults emerged on		Duration (in days)	
	Male.	Female.	Male.	Female.
19.II(M)	28.II(M)	5.III(M)	9	14
18.III(M)	24.III(M)	28.III(M)	6	10
4.IV(M)	7.IV(M)	9.IV(M)	3	5
10.V(E)	12.V(E)	13.V(E)	2	3
1.VI(E)	3.VI(E)	4.VI(E)	2	3
4.VII(M)	5.VII(E)	7.VII(M)	1½	3
16.VIII(M)	18.VIII(E)	19.VIII(E)	2½	3½
14.IX (E)	17.IX(E)	18.IX(E)	3	4
13.X(E)	18.X(M)	19.X(E)	4½	6
29.X(E)	3.XI(E)	5.XI(E)	5	7
17.XI(M)	25.XI(M)	28.XI(M)	8	11
17.XII(M)	30.XII(M)	2.I(M)	13	16

Life-cycle.—Generations overlap in nature and all stages of the mite are available throughout the year. Under controlled conditions, as many as thirty generations were counted in the course of a year.

TABLE IV. *Duration of life-cycle of* P. indicus *Hirst*

Eggs laid on	Adults emerged on		Duration in days		Temp. F.°	
	Male	Female	Male	Female	Min.	Max.
11-I(M)	28-II(M)	5-III(M)	48	53	42.0	70.6
9-III(M)	24-III(M)	28-III(M)	15	19	52.1	83.0
30-III(M)	7-IV(M)	9-IV(M)	8	10	60.3	91.4
7-V(E)	12-V(E)	13-V(E)	5	6	80.3	106.5
15-VI(M)	21-VI(M)	22-VI(M)	6	7	78	91.8
1-VII(E)	6-VII(M)	7-VII(M)	4½	5½	81.0	103.6
22-VIII(M)	27-VIII(E)	28-VIII(E)	5½	6½	78.6	94.0
19-IX(E)	25-IX(E)	26-IX(E)	6	7	70.7	93.3
8-X(E)	18-X(M)	19-X(E)	9½	11	59.7	88.4
22-X(E)	3-XI(E)	5-XI(E)	12	14	53.9	81.7
9-XI(M)	25-XI(M)	28-XI(M)	16	19	45.1	75.7
4-XII(M)	30-XII(M)	2-I(M)	26	29	3	69.0

The duration of the life-cycle depends upon the season : in males, it occupies $4\frac{1}{2}$-6, 8-16, and 26-48 days during mid April-September, March, and October-November, and December-February respectively, while in the case of the females it lasts for $5\frac{1}{2}$-7, 10-19, and 29-53 days during the corresponding periods (Table IV).

Viability of eggs and the percentage of larvæ attaining adult stage is normally high (Table V), the depression period for the former being July and for the latter May and July.

TABLE V. *Viability of eggs and the percentage of larvæ attaining adult stage*

Month	Number of eggs laid	Number of eggs hatched	Number of adults emerged	Percentage hatching	Percentage larvæ attaining adult stage
April	62	59	58	95.2	98.3
May	100	93	81	93.0	87.1
June	113	109	103	96.5	94.5
July	59	54	50	91.5	92.6
August	90	85	83	94.4	97.6
September	106	102	99	96.2	97.1
October	91	88	85	96.7	96.6
November	38	38	38	100.0	100.0

Web-formation

The females move about briskly for sometime on a healthy leaf before settling down along its mid-rib and spinning a web. At first the mid-rib and the leaf lamina are used for fixing the ends of silken threads but later on they are fixed indiscriminately, the web finally forming a small thick covering on the lower surface of the leaf. Eggs are laid singly in the web and the progeny develops underneath it. The webs formed by the females and their progeny on a leaf gradually extend and coalesce with each other with the result that ultimately the entire lower surface of an infested leaf gets covered with what looks like a single web. All stages of this mite are capable of spinning the web but it is usually the female which performs most of this task.

IV. SEASONAL-HISTORY

Paratetranychus indicus Hirst is active on the leaves of *buru* throughout the year. It begins to breed with the rise in temperature in March ; generations follow in quick succession with the result that by the end of April the population increases considerably. It migrates (through the agency of wind) to sugarcane and *chari* seedlings in the beginning

of May. Activity on these crops is maintained up to July when monsoon rains set in and kill all of its stages except the eggs ; it is the eggs which start the infestation at the termination of the rainy season in the end of August. During September-November it is confined to *chari* and *buru*, it does appreciable damage to the former crop in this period. Its seasonal-history calendar is as follows :—

March-April : rapid multiplication on *buru*.

May-mid July : migration to *chari* and sugarcane, damage to these crops at its maximum, also active on *buru*.

Mid July-August: monsoon rains kill all stages except the eggs.

September-mid November: active on *buru* and *chari*. (During this period sugarcane leaves become tough and are not infested).

Mid November-December : all stages available on *buru* in greatly reduced numbers.

January-February : present mostly, as gravid females and eggs, on *buru*.

Sex-ratio at different times of the year

The proportion of sexes varies with the time of the year. In December and January, the male population is lowest, being only about 21%. From February onwards it increases and varies between 40-49% upto November, the maximum male population being in May when the sex-ratio is 49 : 51. The male population declines again after November.

The adult population and the sex-ratio on 10 leaves of *buru* in different months are given in Table VI.

TABLE VI. *Sex-ratio of* P. Indicus *during different months*

Month	Adult population	Number of males	Number of females	Ratio of males and females
March	513	237	276	46 : 54
April	308	123	185	40 : 60
May	139	68	71	49 : 51
June	201	96	105	48 : 52
July	163	72	91	44 : 56
August	275	121	154	44 : 56
September	242	110	132	46 : 54
October	148	61	87	41 : 59
November	104	42	62	40 : 60
December	94	20	74	21 : 79

Parthenogenesis is a common phenomenon in this mite, the parthenogenetically laid eggs producing progeny which consists of 94-96% males.

Dispersal

The pest is commonly distributed through females. Before settling down on a leaf they move about on it usually along its edges, from where they are blown by wind to the neighbouring plants. They have been observed to be thus carried to a distance of over 200 feet. There is reason to believe, however, that wind carries them over even longer distances. In sugarcane and *chari* fields in which leaves touch one another, the females also spread the infestation by crawling from plant to plant.

V. NATURE OF DAMAGE

Paratetranychus indicus Hirst feeds by sucking the plant sap with its stylets. The males feed very rarely, therefore, the damage is done by the females and the larval stages.

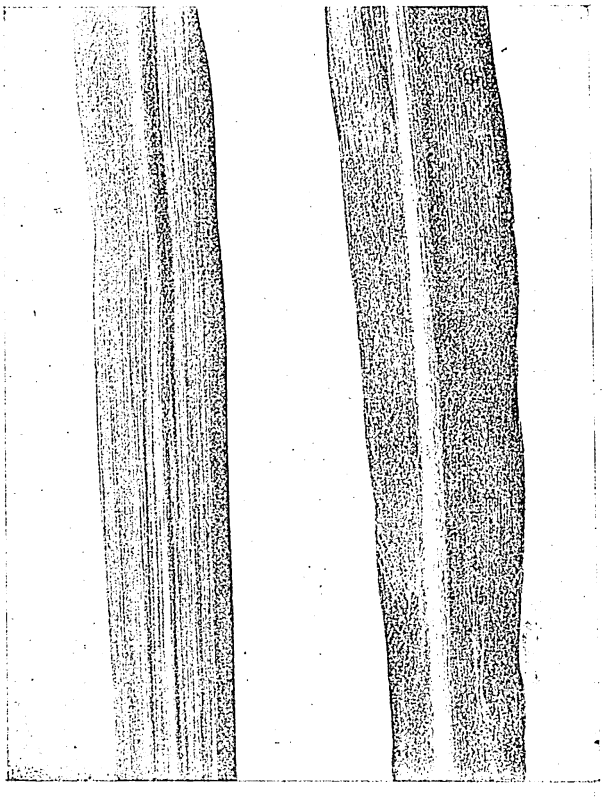

FIG. 12.
Left—Damaged leaf *Right*—Healthy leaf

The injured surface of the leaf is marked by characteristic red spots. With the increase in attack, the red spots increase in size and coalesce, at first forming large red patches and later on spreading over the entire leaf surface. The attacked leaf, because of its red colour, can be detected from a distance (Fig. 12). Such leaves gradually dry up and fall off.

The reasons for the reddening of the attacked leaves need investigation. Microscopic study of such leaves has shown that the red colour is taken up by the leaf tissues. Cultures prepared from the damaged leaves were injected into healthy leaves with negative results. This shows that the red colour is not caused by bacteria or fungi : sugarcane is also attacked by another species of the genus *Tetranychus*, which does not produce any red colour and this leads one to believe that *P. indicus* Hirst probably injects some toxic material into the leaf at the time of feeding which, interacting with the plant juice produces the red colour.

During summer the immature stages can stand starvation up to 8 hours, the females for 24 hours, but the males can live without food for 72 hours.

VI. Varietal preference

It was observed in the fields that soft leaved varieties of sugarcane were more susceptible to the attack of this mite than the varieties with hard and tough leaves. To test this point Coimbatore varieties of sugarcane 205, 301 and 312 were planted in pots, there being ten pots for each variety. When the plants were about a foot high, they were infested with 10 gravid females covered with cellophane bags and allowed to breed unmolested for a month. At the end of this period the total progeny was counted and the results are presented in the following table :—

Variety	Ash : water	Mite population		
		Eggs	Active forms	Total
Co 205	1 : 23.907	143	117	260
Co 301	1 : 26.483	197	246	443
Co 312	1 : 27.315	372	317	689

VII. Acknowledgement

We are grateful to Mr. M. Afzal Husain, formerly Entomologist to Government, Punjab, for suggesting the problem and for his help and guidance during its progress until his appointment as Vice-Chancellor of the University of the Punjab, in 1938.

VIII. SUMMARY

Paratetranychus indicus is widely distributed in India and the names of the localities in the Punjab are given. In Southern India it infests sugarcane, *cholam* (*Andropogon sorghum*) and two grasses, *Panicum javanicum* and *P. distachyum*, but in the Punjab it feeds upon sugarcane, *chari* (*Sorghum vulgare*) and *buru* (*Sorghum halepense*).

Its egg, larva, and mode of web-formation are described. The Life-history is described in more detail. It is shown that the duration of the oviposition, preoviposition and postoviposition periods, as well as that of the egg and larval stages depends upon the season. During the active period (mid April-September) the life-cycle is completed in $4\frac{1}{2}$-6 days in the male and $5\frac{1}{2}$-7 days in the female. Seasonal-history calendar is given and it is shown that the damage by this pest is at its peak during May to mid July. The proportion of sexes varies with the season, the sexes being almost equal in number during May.

The pest is distributed through females which are either blown to the healthy plants by wind or crawl to those whose leaves come into contact with those of the infested ones. Damage is done by the females and the larvæ. The attacked leaves turn red, gradually dry up and fall off. Sugarcane varieties with soft leaves are more susceptible to the attack of this mite than those with hard and tough leaves.

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THE ALTERNATE HOST PLANTS AND ASSOCIATED PARASITES OF *PEMPHERES AFFINIS* FAUST IN SOUTH INDIA

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CONTENTS

I. INTRODUCTION

One of the interesting phases in the investigation of the cotton stem weevil, *Pempheres affinis* Fst. proved to be the study of its alternate host plants. In spite of the fact that the insect has been known as a serious pest of exotic and indigenous cottons for the last quarter of a century, there is still no definite information on this aspect. A regular and quantitative survey of its food plants was, therefore, undertaken in 1937. The studies were, perforce confined to Coimbatore and its immediate environs, save a few occasional observations in other regions. As a result, the weevil has been observed definitely to occur and breed in several other plants besides cotton, and the identity, distribution and status of such host species have been established.

Apart from a description of the host-range of this weevil, the outstanding feature of this contribution is the discovery of parasites associated with them. No parasites were hitherto known from alternate hosts, from which about ten species of parasites have now been discovered. Most of these are not found in cotton fields and also appear to be new to science.

II. REVIEW OF PREVIOUS WORK

Much of the previous knowledge on this subject appears to have been based on casual observations. Since the original description

of *P. affinis* by Faust in 1898, the first observations on possible wild food plants were made by Lefroy (1909) when he reported the weevil as being common in the stems of malvaceous plants. Fletcher (1913) recorded *Hibiscus cannabinus* (*gogu*) under host plants besides the exotic varieties of cotton, the primary host. The same author (1917) added *Hibiscus esculentus* (*bhendi*) and Indian hemp (*Cannabis sativa*) to the list of the plants from which the weevil had been bred at Pusa. Ramakrishna Ayyar (1918) recorded *gogu* and *bhendi* as hosts from South India. Fletcher again (1919) referred to *Pempheres* as having been bred from *Triumfetta* sp. from Pusa. He further added that the insect may breed in *Hibiscus* spp., hollyhock and wild malvaceous plants, such as, *Sida* spp., *Abutilon indicum* and *Thespesia populnea*. Ballard (1922) observed the weevil freely breeding in *Corchorus olitorius*, in two species of *Abutilon*, and in *Hibiscus rosa-sinensis*, besides others already noted. The same author also provided a list of about 13 food plants known till then. Dharmarajulu (1934) stated that the weevil is unable to breed on any alternate host plant except *Corchorus*. Gardner (1934) mentioned the weevil as having been reared from *bhendi*, *Urena lobata* and hollyhock from Dehra Dun District. Ramakrishna Ayyar and Margabandhu (1936) again discussed the question and stated that it had not been seen actually breeding on any other plant except, to a small extent, on *bhendi*, stray *Corchorus* plants and *gogu*.

It is evident from the above that the food plants of the insect are only imperfectly known. The earlier accounts, besides being vague and conflicting, do not include the exact specific names of some of the host plants. Data on incidence, seasonal distribution, extent of attack, susceptibility and status are not available. It is, therefore, inevitable that, in the main, such accounts have been open to question by subsequent workers. For instance, mention has been made of *Triumfetta* sp. Three species, namely, *T. rotundifolia*, *T. pilosa* and *T. rhomboidea* are common but it is only the third which has been found by the writer to be infested. Some species, e.g., *Abutilon indicum*, *A. glaucum*, *A. hirtum* and *Hibiscus rosa-sinensis* have failed to show any weevil infestation in spite of detailed examination.

III. FOOD PLANTS

The examination of over 20 thousand plants afforded an opportunity for the evaluation and interpretation of the inter-relationship between the weevil and its host plants. Only those plants are considered as hosts wherein the weevil has been noted to feed and breed. The majority of such hosts comprise wild plants. These mostly belong to the natural orders, Malvaceæ and Tiliaceæ, with a species or two of Sterculiaceæ. In the following list the species are *not* enumerated in the order of preference or intensity of infestation.

Malvaceæ—(1) *Althæa rosea*, (2) *Malvastrum coromandelianum*, (3) *Sida glutinosa*, (4) *S. spinosa*, (5) *S. acuta*, (6) *S. rhombifolia*, (7) *S. rhomboidea*, (8) *S. cordifolia*, (9) *Hibiscus ficulneus*, (10) *H. vitifolius*, (11) *H. esculentus*, (12) *H. cannabinus*, (13) *Urena lobata*, (14) *Pavonia zeylanica*.

Tiliaceæ.—(15) *Triumfetta rhomboidea*, (16) *Corchorus olitorius*, (17) *C. acutangulus*.

Besides the above, four species, namely, (1) *Urena sinuata*, (2) *Hibiscus surattensis*, (3) *H. micranthus* and (4) *Melochia corchorifera* have frequently shown typical symptoms of weevil-infestation as revealed by the nature of injury, shape and size of tunnels and remains of immature stages of the weevil. Conclusive evidence in the shape of live stages has seldom been obtained and therefore, these plants have been grouped under tentative or doubtful hosts. A further record of two species, namely, *Ficus carica* (edible fig) and *Hibiscus rosa-sinensis* should be included under doubtful or partial hosts since the adult weevils have been taken occasionally resting on the stems of these plants. These plants probably afford a kind of temporary shelter and food for the adults. The following species have not been recorded previously and may be considered as new records:—*Malvastrum coromandelianum*, *Sida glutinosa*, *S. acuta*, *S. rhombifolia*, *S. rhomboidea*, *S. cordifolia*, *H. ficulneus*, *H. vitifolius*, *Pavonia zeylanica* and *Corchurus acutangulus*. Besides, *Urena lobata* and *T. rhomboidea* may also be considered in a way, as new, since the former had not been noted as host in South India and the latter had not been specifically defined.

IV. Incidence of the weevil in different hosts

Some species are more heavily infested than others, apparently largely due to differences in attractiveness and palatability. In the case of cotton even very young plants about two weeks old are subject to the attack, whereas in most other host plants the attack begins after 4 or 5 weeks growth. In all species the initial incidence is low and populations are built up gradually except in the case of *T. rhomboidea*. Cotton is not so heavily infested and does not harbour such large populations as some other species, e.g. *T. rhomboidea*. In most cases the characteristic galls are developed, making the infestation conspicuous.

Malvaceæ.—*Althæa rosea*.—This is extensively cultivated as an ornamental plant throughout India. Numerous plants of this species have been examined by the writer from Coimbatore and Dehra Dun and all stages of the weevil have been recovered. Gardner (1934) has also recorded this as a host of *Pempheres*. The grubs tunnel extensively in the lower portions of the stem. The maximum number of live stages collected per plant has

not exceeded ten. The parasite, *Aplastomorpha calandræ* (How.) has been bred from the weevils on this plant.

Malvastrum coromandelianum Garcke.—This is a small erect herb, very widely distributed in all situations. In some areas, such as wooded tracts and valleys, large stretches of this weed may be observed. In isolated patches it may be taken anywhere along road-sides, waste lands and near cotton fields and occupies an important place as a source of reinfestation of cotton. Large healthy eggs are laid deep in the comparatively soft stem. Larval tunnels extend often to the region of the tap root where pupation takes place. The stems are often too small and tiny for the grubs to attain maximum size. When the stems are sufficiently thick, fairly large galls are met with at their bases. Infestation may rise up to 80% (Table I). Maximum infestations are found in the close season, during June to October. Three species of parasites have been recovered in association with this plant—two Chalcids, *Entedon pempheridis* Ferr. and *Euderus pempheriphila* Ramakr. & Mani, and a Braconid, *Spathius critolaus* Nixon.

Sida glutinosa Cav.—This hairy herb, though found throughout S. India, does not appear to be an abundant species. The plant has been occasionally observed near cotton fields and may be considered as a minor host. A total of 225 plants has been examined and the normal rate of infestation was found to vary between 6 and 33%, but higher percentages, nearing the maximum, have occurred under exceptional conditions. This species reveals maximum infestations during the off-season—May to October. In cage trials, oviposition is fairly normal and eggs are large and healthy. In recording data, the attacks and tunnels of a common Buprestid borer, *Agrilus acutus* Thumbg., have to be carefully distinguished and excluded.

Sida spinosa Linn.—This is a hairy shrub, widely distributed in all places. It rarely occurs near cultivated fields. Comparatively large populations of live stages of *Pempheres* are occasionally found during the close season for cotton. On the other hand, infestation is practically absent during the cotton season (October to March). A Chalcid parasite, *Dinarmus coimbatorensis* Ferr.* was reared from this host during July 1937.

Sida acuta Burm.—This species may be classed as a major and important host, not merely from the view-point of incidence but also of parasitism. It is a much-branched, erect and widely distributed shrub. Vast stretches of these plants are found in forest regions and hill slopes having plenty of rainfall. Small numbers can be taken in uncultivable

* *Dinarmus coimbatorensis* Ferr. is synonymous with *Dinarmus sauteri* Masi, recorded from Madras and Pusa. *Vide* Pruthi & Mani, *I C A R. Misc. Bull.*, 30 : 9, 1940—[*Ed.*].

TABLE I. *Consolidated Data on Alternate Food Plants* (1937-1940)

No.	Name of plant	Total No. examined	Infestation		Live population		Parasitism	
			Av. %	Maxm. %	Av. %	Maxm. %	Av. %	Maxm. %
1.	*Corchorus olitorius*	1527	15.8	51.5	19.99	95.3	0.68	16.0
2.	*Triumfetta rhomboidea*	6023	79.0	100.0	270.37	2078.0	10.61	32.0
3.	*Urena lobata*	32	6.7	25.0	12.5	12.5	—	—
4.	*Hibiscus cannabinus*	331	35.99	80.0	22.34	120.0	—	—
5.	*Hibiscus esculentus*	381	17.1	30.5	3.3	8.3	—	—
6.	*Hibiscus vitifolius*	1431	8.6	40.0	5.01	20.0	1.3	40.0
7.	*Hibiscus ficulneus*	740	2.2	16.6	1.41	13.0	—	—
8.	*Sida rhomboidea*	289	13.6	36.0	7.8	27.0	—	—
9.	*Sida rhombifolia*	109	4.6	50.0	59.0	150.0	—	—
10.	*Sida acuta*	5739	15.1	80.0	6.1	89.2	2.75	66.6
11.	*Sida glutinosa*	225	24.3	100.0	22.1	286.9	—	—
12.	*Sida spinosa*	162	14.7	73.0	22.6	118.0	2.1	27.6
13.	*Malvastrum coromandelianum*	4863	13.3	41.5	5.84	50.0	0.72	15.3
14.	*Pavonia zeylanica*	229	4.6	33.3	11.65	100.0	0.91	9.1
15.	*Althæa rosea*	230	15.3	34.7	33.33	100.0	0.76	2.28
16.	*Sida cordifolia*	57	11.10	100.0	22.20	100.0	—	—
17.	*Corchorus acutangulus*	141	6.63	75.0	6.82	75.0	—	—

waste lands. This host was discovered by the writer at Dehra Dun in November, 1936. Since then extensive collections of plants have been made from Wallayar, Dhone, Kallar, Siruvani, Mangarai forests, Thondamuthur and Coimbatore, and these have invariably shown high percentages of infestations, sometimes rising up to 80%. Fairly large numbers of immature stages of the weevil have been noted but not in proportion to the total infestations recorded. The mode of attack, the course of tunnelling and other habits are slightly different from those in other plants. In cage trials the oviposition is good and rather profuse if there is a supply of fresh stems. The eggs are not, however, laid sufficiently deep in the stem, being found just below the epidermis, a little away from the scars left after oviposition. Often the eggs are elongated in shape due to pressure and want of sufficient room in the shallow egg-cavity. The grubs, after a brief journey round the stem, enter the central pith and work their way for long distances either up or down in the stem. Pupation takes place in any part of the central tunnel or more often near the roots without the usual exit tunnel connecting the pupal chamber to the epidermis. Many adults and immature stages have been observed dead *in situ*, the former, probably being unable to emerge through the hard woody enclosure. A number of adults which emerge are small in size, probably due to starvation and may be looked upon as " runts ". The plant seems to be attractive and suitable in its early growing stage, particularly for oviposition, but seems to develop certain physical drawbacks in its later stages of growth, such as hard texture and lack of enough moisture, which are not good for the weevil. Notwithstanding this disability, this host is remarkable for the variety of parasites associated with it, though not for their abundance. Six species of parasites consisting of two Braconids, *Rhaconotus cleanthes* Nix. and *Spathius critolaus* Nix., and four Chalcidoids, *Eupelmus urozonus* Dalm., *Entedon pempheridis* Ferr., *Dinarmus coimbatorensis* Ferr. and *Aplastomorpa calandræ* (How.), have been reared from this material. While examining this species for *Pempheres* attack, great care is necessary to distinguish more or less similar infestations due to the common Buprestid borer, *Sphenoptera gossypii*.

Sida rhombifolia Masters.—This is a common shrub occasionally found in uncultivated lands and forest areas. This has been collected in small numbers from Coimbatore and Thondamuthur. This plant was for the first time noted to harbour the weevil from collections made in Dehra Dun by the writer. In Coimbatore and its environs the weevil has been observed to breed in this plant in small numbers. One peculiarity noted in the habits of the weevil is that pupation takes place very often near about the root region. This is not a very important host.

Sida rhomboidea Roxb.—The distribution of this perennial host is apparently limited. It is common in waste lands, borders of canal

bunds and forest regions. It has seldom been taken from or near cotton fields. Owing to insufficient opportunities only 289 plants have been examined and the highest percentage of weevil incidence recorded is only 36. Appreciable populations of the weevil have not been observed on this plant, which may, therefore, be considered as of minor importance.

Sida cordifolia Linn.—This is a weed of road sides and other waste lands, often found also in forests in numbers. The species has shown only a slight weevil infestation.

Hibiscus ficulneus Linn.—This annual herb with prickly leaves and stems is a fairly common species both in waste and cultivated places. In certain situations and seasons, considerable numbers could be taken in or around cotton areas. The highest percentage of incidence recorded has not exceeded 16.6%. Very often it has shown only slight infestations. As seen from field collections and laboratory trials, the species is not very attractive to the weevils, particularly in its early stages, probably due to the rough surface and juicy nature of the stem. Oviposition in the species has been noted to be poor and occasional. The infestations in this species apparently occur only when it grows in the vicinity of heavily infested cotton fields. A Braconid parasite, namely, *Spathius critolaus* has been taken parasitising the weevil grub in association with this species.

Hibiscus vitifolius Linn.—This tall hairy annual herb is fairly abundant in garden waste lands, water courses and jungles. The rate of weevil incidence has been uniformly low, though the maximum has risen up to 40% on rare occasions. The plant is not very attractive for oviposition. The eggs are placed almost superficially and partially sunk in the epidermis. An average of 20 live stages per 100 plants is the maximum recorded for the period and the species is evidently unsuitable for building up heavy populations. Another weevil belonging to the genus *Lobotrachelus* occurs as an occasional borer in the stems and the grubs of this species have to be distinguished from those of *Pempheres* for accurate recording. The Chalcid parasite *Entedon pempheridis* has been taken in small numbers parasitising *Pempheres* grubs found on this plant.

Hibiscus esculentus Linn.—This plant, widely cultivated throughout India as a vegetable, has been frequently found badly infested by this weevil not only in the vicinity of cotton fields but also from localities devoid of any cotton cultivation such as Malabar, Manantoddy hills and Dehra Dun. Probably some wild hosts of the weevil in such situations form the nucleus of infestation. Very heavy incidence has been noted in some situations. Hundreds of plants have been examined from diverse localities but recorded data cover only a small proportion. This plant is attractive only in its later stages of growth due to excessive mucilaginous nature of the stems in early stages. This host, particularly the material from

west coast, seems to be a good source for parasites. *Dinarmus coimbatorensis* among Chalcids and *Rhaconotus* spp. and *Spathius* spp. among Braconids have been recovered from this source.

Hibiscus cannabinus Linn.—Extensive collections of this cultivated plant have been examined from various localities but records of data have been maintained only for 331 plants. The infestation is appreciable only in the vicinity of cotton crops. As high a percentage as 80% has been noted. The various stages, particularly the grubs, are very healthy, robust and large-sized and in this regard stand only second to those breeding in *Triumfetta rhomboidea.*

Urena lobata Linn.—This widely distributed shrub has been taken mostly from forest areas although stray isolated specimens occur in all waste places. Occasionally this species has been observed to be infested by the weevil. Gall formation also occurs at times. More frequently another weevil, *Lobotrachelus* sp., has been found on this plant. Occasionally Buprestid borers are also met with. Such infestations and insect stages have to be differentiated from those of *Pempheres*. This species has been recorded as a host of *Pempheres* by Gardner (1934) from Dehra Dun. The writer has collected the weevil and its immature stages from Dehra Dun as well as from Coimbatore and environs. The species is not very abundant and, therefore, data are available only for a small number. The infestation sometimes rises to 25%, but live stages collected are only a few. In laboratory trials oviposition is comparatively heavy but survival of later stages appears to be difficult due to the hard and woody structure of the stem. Various parasites have been bred in association with the plant, particularly from Dehra Dun but their definite relationship with *Pempheres* is uncertain.

Pavonia zeylanica Cav.—This is found near cultivated regions. In forest areas small numbers are obtainable and very small percentages of attack have been noted. A Braconid parasite, *Spathius critolaus,* has been occasionally bred from *Pempheres* infesting this plant.

Tiliaceæ.—*Triumfetta rhomboidea* Jacq.—This is a common weed in all kinds of uncultivated waste lands, but not found in any considerable numbers near cotton fields. Large stretches of this plant have been observed in moist regions like Wallayar, Kallar, Mankarai forests, and Siruvani. The species appears to present the most favourable ecological conditions for the reproduction and development of the weevil. The plant is attractive in all, except perhaps in its earliest stage, and all parts of the stem and branches possessing the requisite thickness are seen to be attacked. Extensive collections of over 6000 plants have been made from a variety of localities and the data are given in the tables. Huge populations of the weevil are built up in the course of a season. The stem

is both soft and succulent and is apparently well suited for food and continuous multiplication. As many as 500 individuals in a single plant have been recorded. Major fluctuations in populations can be to a great extent accounted for and correlated with such factors as growth-condition and age of the plant in conjunction with the meteorological conditions of the locality. The species carries heavy infestation even where cotton cultivation is unknown. The incidence of the weevil and its parasitism in this host have already formed the subject of a paper by the writer. Some marked deviations in the mode of infestation of the weevil in relation to this plant have been recorded. The oviposition is more towards the surface of the stem and the eggs are only slightly sunk in the bark. Occasionally the eggs are even partially exposed. The small grubs on hatching often penetrate immediately into the soft stem without any circuit round the stem. Numerous galls are frequently developed in stem and even thin branches. The bulk of the parasite collections has been obtained from this species. About 1100 parasites belonging to eight or nine different species, besides a Nematode parasite and a few predators, have been bred from *Pempheres* in association with this host-species. They are *Entedon pempheridis* Ferr., *Dinarmus coimbatorensis* Ferr., *Aplastomorpha calandræ* (How.), *Euderus pempheriphila* Ramakr. & Mani and *Bruchocida orientalis* Crawf. (Chalcidoidea) and *Spathius labdacus* Nix., *Spathius critolaus* Nix., *Rhaconotus cleanthes* Nix. and *Rhaconotus menippus* Nix. (Braconidæ). The great majority of these are absent in cotton fields and *S. labdacus* has not been noted from any other food plant. The dominant species in point of numbers is *E. pempheridis* Ferriere.

Corchorus olitorius Linn.—This is a common annual in gardens, cultivated grounds and waste lands after the rains and can be taken from and near cotton fields, paddy lands and cocoanut topes. Two other species are also equally common, viz., *C. trilocularis* and *C. capsularis*, which have been repeatedly examined and found to be free from *Pempheres*. This species forms an important host and over 1500 plants have been examined but the percentage of incidence has been always low, except on rare occasions. Another and much smaller weevil, *Apion corchori*, is frequently found to be a common borer of this plant and its infestation has to be carefully distinguished. This latter weevil species is also seen parasitised by *E. pempheridis* and such records have been carefully kept out of the data presented here. This plant probably forms an important link in the sequence of weevil hosts during the off-season. It may be considered, therefore, as one of the important foci for reinfestation of cotton. It is evident that these plants are comparatively free during the cotton season and the incidence steadily rises during the close season from April to October. In cage experiments, oviposition is fairly good on the plants,

though the stem appears to be not quite suitable as food for the grubs and adults.

Corchorus acutangulus Lam.—This is a fairly common undershrub in pastures, cultivated lands and wooded areas. The species is occasionally infested and live stages of *Pempheres* have been taken in some numbers.

Four species of parasites have been noted in association with this plant, namely, *E. pempheridis*, *D. coimbatorensis*, *R. menippus* and *S. critolaus*.

It will be evident from the above data that *Pempheres* has a variety of hosts on which it feeds and breeds. The list is by no means complete and it may be safe to predict that further intensive and extensive search in the same localities and other regions would bring substantial additions to the present list. A particularly promising field for such a campaign appears to be the entire west coast, with its rich flora of probable hosts.

V. BEHAVIOUR OF THE WEEVIL IN DIFFERENT HOSTS

Among cultivated plants cotton is evidently the most preferred host of *P. affinis*. In hill tracts and regions far away from cotton cultivation it chiefly infests wild plants, its most favourite host being *T. rhomboidea*. The two preferred hosts are so markedly different that they present two distinct types of environmental conditions. The weevil population in *T. rhomboidea* has been practically confined to this host for generations in forest areas and the possibility of admixture with cotton population is negligible. Certain behaviouristic differences between the two populations have also been noted, although no morphological differences are to be found. The mode of attack in the two hosts, the parts attacked and the density of population supported by them show significant deviations. A significant decline in population in cotton beginning from its third generation is also evident. The two host-species differ in their growth, in texture of bark, in hardness of the stem, in taste and odour and probably also chemically in the nutriment afforded. In them there are also two distinct sets of parasite populations, those associated with *T. rhomboidea* being absent in cotton fields. In some preliminary laboratory tests on oviposition, the *Triumfetta* populations have shown poor layings on cotton. A few preference tests in cages when both the hosts are presented simultaneously have shown distinct preferences for the respective parental hosts. The copulation, however, appears to occur freely between the two populations. Probably the separation in the two hosts is not sufficiently strong and distinctive, the weevil being polyphagous. Some olfactometer tests have also been made but these have been too few to give any definite results. The observations recorded above are, however, strongly suggestive of the possibility of the species having different strains.

VI. Natural enemies associated with different plant hosts

A list of parasites of *Pempheres* in association with food plants other than cotton is furnished below. Previous to these studies no such parasites were known, the majority of which have proved to be new to science. Five species among these are absent in cotton fields. The majority of these have shown the ability to parasitise the pest in several different plants, including wild species. Some of these have been studied in some detail but only a brief account is presented here. As many as 1145 specimens have been collected from various hosts. The percentage of tota lparasitism is recorded in the table.

Ten species (six Chalcidoids and four Braconids) besides a Nematode parasite, have been recovered from the weevil in association with one or more of its food plants. All the parasites noted are larval and ectophagous except one endophagous species.

Insect Parasites

Chalcidoidea—*Entedon pempheridis* Ferriere.—This is the only endophagous species so far noted on *Pempheres*, the egg and larval periods being spent inside medium-sized or mature host grubs. After consuming the entire contents the full grown larva issues out by the crumblings of the empty host cuticle. It turns into a prepupa soon after and pupates in the host tunnel. After about 10-13 days the adult emerges. Never more than a single parasite has been found in one host. This species has been the most numerous. As many as 589 specimens have been obtained, of which 571 were from *T. rhomboidea*, 3 from *S. acuta*, 10 from *C. olitorius* and 1 from *Malvastrum* and 4 from *H. vitifolius*. It is widely distributed and occurs all the year round, but the largest numbers are seen from September to November.

The other insect hosts from which this parasite has been collected are *Apion* grubs on *C. olitorius*, *Lobotrachelus* grubs on *H. vitifolius* and *H. manihot* and *Hypolixus** on *Amarantus*. The species is absent in cotton fields and apparently possesses considerable possibilities.

Dinarmus coimbatorensis Ferr.—This is a primary larval parasite with a partiality for full grown grubs. It has been successfully reared in the laboratory and its life-cycle occupies 17 to 23 days. Only one larva develops to maturity even if two, three or four eggs are laid in one host. As many as 179 specimens have been collected, of which 153 were from *T. rhomboidea*, 17 from *S. acuta*, 6 from *C. olitorius*, 2 from *S. spinosa* and one from *H. esculentus*. It occurs in all localities and in all

* *Hypolixus* is considered by numerous authorities to be a subgenus of *Lixus*; and the species referred to here is called *Lixus* (*Hypolixus*) *truncatulus* (Boh.)—[*Ed.*].

seasons—July to December being the most favourable period. The only other host from which the species has been recovered is *Hypolixus* on *Amarantus*. It is absent in cotton fields.

Eupelmus urozonus Dalm.—This is the first record of this common palæarctic species in India. Only one parasite develops from a single host and the life-cycle occupies from 14 to 17 days. It has been taken in Malabar and Coimbatore. One specimen has been collected from *Sida acuta* and 3 specimens from cotton. *Hypolixus truncatulus* on *Amarantus* forms an alternative host for the parasite and several recoveries have been made from this host.

Bruchocida orientalis Crawford.—A single female specimen has been collected as pupa from *Pempheres* on *T. rhomboidea* in July, 1937. The species is known as a parasite of *Bruchus chinensis* in South India.

Euderus pempheriphila Ramakr. and Mani.—This minute Eulophid attacks medium-sized and full-grown grubs. Only one parasite develops from a single host even though more than one egg is laid. Life-cycle takes from 12 to 18 days. It is the most numerous of parasites of *Pempheres* found in cotton fields. This species is subject to the attack of a hyper-parasite, *Eupelmella pedatoria* in cotton fields. Three parasite specimens have been collected from *T. rhomboidea*, 1 from *S. acuta* and 1 from *Malvastrum*. *Hypolixus* on *Amarantus* forms another host for the parasite.

Aplastomorpha calandræ (Howard).—This is a cosmopolitan species, usually parasitic on beetle pests of stored products such as *Calandra*, *Sitodrepa*, *Lasioderma*, *Bruchus*, etc. Probably the first record of its parasitism in stem-boring Curculionids is on *Pempheres*. Never more than one parasite develops from a single host even though two or more eggs are laid on the same. The life-cycle occupies 16—17 days. Parthenogenesis is common, giving rise to male progeny. Only three parasites have been collected from this source, 2 from *T. rhomboidea* and 1 from *Sida acuta*. Larger numbers have been obtained from cotton fields.

Braconidæ—*Spathius critolaus* Nixon.—This reddish-brown Braconid is a parasite which occurs most commonly; the micropterous form, though rare, is taken in greater numbers among females than males. Being a common parasite in cotton fields, its life-history and possibilities have been fully worked out, and it has formed the subject matter of a separate paper. The life-cycle occupies from 13 to 27 days according to season and host. Nearly 22 specimens of the species have been obtained of which 14 were from *T. rhomboidea*, 3 from *S. acuta*, one each from *C. olitorius*, *Malvastrum*, *Hibiscus ficulneus*, *H. esculentus* and *P. zeylanica*, besides one from *Melochia corchorifera* which has been classified as a tentative host of *Pempheres*. Other known hosts of the species are the

Buprestid, *Sinoxylon sudanicum* boring into cotton stalks and *Hypolixus* on *Amarantus*.

Spathius labdacus Nixon.—This is a large reddish-brown winged species with a long ovipositor. It is primary and ectophagous on full grown host grubs. The life cycle covers 17—22 days. It has been found so far only in association with *T. rhomboidea*. As many as 303 parasite specimens have been collected. It may prove to be an efficient parasite if it could adapt itself to cotton-field conditions.

Rhaconotus menippus Nixon.—This dark-brown Braconid attacks full grown host grubs. The life-cycle occupies 16 to 24 days. It reproduces parthenogenetically, giving rise to male off-spring. It is entirely absent in cotton fields. Only two specimens have been bred—one female from *C. olitorius* in August 1937 and another from *T. rhomboidea* in June 1938. Larger numbers have been obtained from another host, viz., *Hypolixus* on *Amarantus*.

Rhaconotus cleanthes Nixon.—This species is reddish-brown in color. The life-history and habits are probably similar to those of the other species but it is very difficult to make it (oviposit) in captivity. Nearly 35 specimens have been obtained of which 27 were from *T. rhomboidea* and 8 from *Sida acuta*. One specimen closely resembling this species has been reared from *Pempheres* on *H. esculentus* in Malabar. The species does not occur in association with cotton.

Non-insect parasites

Nematode—*Geomermis indica* Steiner is perhaps the first record of a Nematode parasitic on *Pempheres* and has been reported already (*Indian J. Ent.*, 1940, 2(1) : 96—97). As many as eleven worm larvæ have been dissected out from one host.

Predators

Two species of ants belonging to the genera *Sima* and *Monomorium* have been frequently taken from *Pempheres* tunnels in *T. rhomboidea*, particularly from old plants having emergence holes of adult weevils. These have been observed to colonise in the interior of such tunnels and devour the immature stages particularly grubs and prepupæ of *Pempheres*. Another Arthropod which has been noted in some numbers in association with *Pempheres* tunnels in *T. rhomboidea* is a species of Chelifer. This is only a suspected predator yet.

VII. Sources of infestation of cotton crop

Information in regard to the food cycle of *Pempheres affinis* Fst. is incomplete. Much of the breeding takes place in cotton, during the

major portion of the year. But in the off-season the question of its survival and sources of reinfestation assumes great importance. The possible sources in this regard come under three categories :—(1) A small population which survives through the off-season even under unfavourable conditions. (2) More important source is the trash of pulled-out cotton stalks which are often kept stacked for fuel, thatching or fencing purposes. Recent studies on duration of emergence in such material have shown that a fraction of the population may continue to emerge and survive for a period of over two months. Such survivals also may be regarded as insignificant from the view point of numbers. (3) It is the third source, namely, alternate food plants, of which there are seventeen species as shown by the present study, that constitutes a real menace. Among these, the most important is *T. rhomboidea*, which seems to maintain a large population independently of cotton. It may well nigh appear to be an impossible task to eradicate this plant host on account of its wide distribution and abundance. Fortunately, the weevil has developed such a high degree of preference for this food plant that only a negligible fraction can take to cotton directly. It appears to require some intermediary hosts before its influx into cotton fields. Among such intermediaries, *Malvastrum* and *C. olitorius* are the commonest in and near cotton areas and these can easily be eradicated with some little effort. Often during the off-season, due to adverse weather, such as extreme drought, their sprouting is arrested and the few that spring up, get dried up and thus undergo natural extermination. A clean-up campaign directed against such common weed hosts will be immensely useful in reducing the rate of infestation in the succeeding cotton crop.

VIII. ACKNOWLEDGMENTS

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IX. SUMMARY

An interesting phase of the investigation on the cotton stem weevil *Pempheres affinis* Fst. proved to be the study of its alternate host plants.

Information available on them was meagre and somewhat contradictory. The present study, therefore, was commenced in 1937. *Pempheres* is now known to breed in about 17 different species of plants belonging mainly to Malvaceæ and Tiliaceæ of which about twelve are new records. Quantitative data on incidence, population, locality, season, extent of attack, susceptibility, etc., are presented. Brief notes on nature and mode of attack with brief ecological observations on distribution and abundance are also furnished. The more important of these hosts are *Triumfetta rhomboidea, Sida acuta, Corchorus olitorius, Malvastrum coromandelianum, Sida glutinosa, Hibiscus esculentus, H. cannabinus, H. vitifolius, Pavonia zeylanica and S. spinosa.*

Some of the hosts derived their infestation from the primary host cotton, whereas others showed that their infestations had had an independent origin. *T. rhomboidea* appears to be the most preferred among wild hosts. The discovery of a new unrecorded set of parasites in association with these host plants is of importance, particularly because no parasites were known hitherto from this source. The more numerous and important among these are *Entedon pempheridis* Ferr., *Dinarmus coimbatorensis* Ferr., *Spathius labdacus* Nixon, and *Rhaconotus cleanthes* Nixon. Their entire absence in cotton fields is of additional significance.

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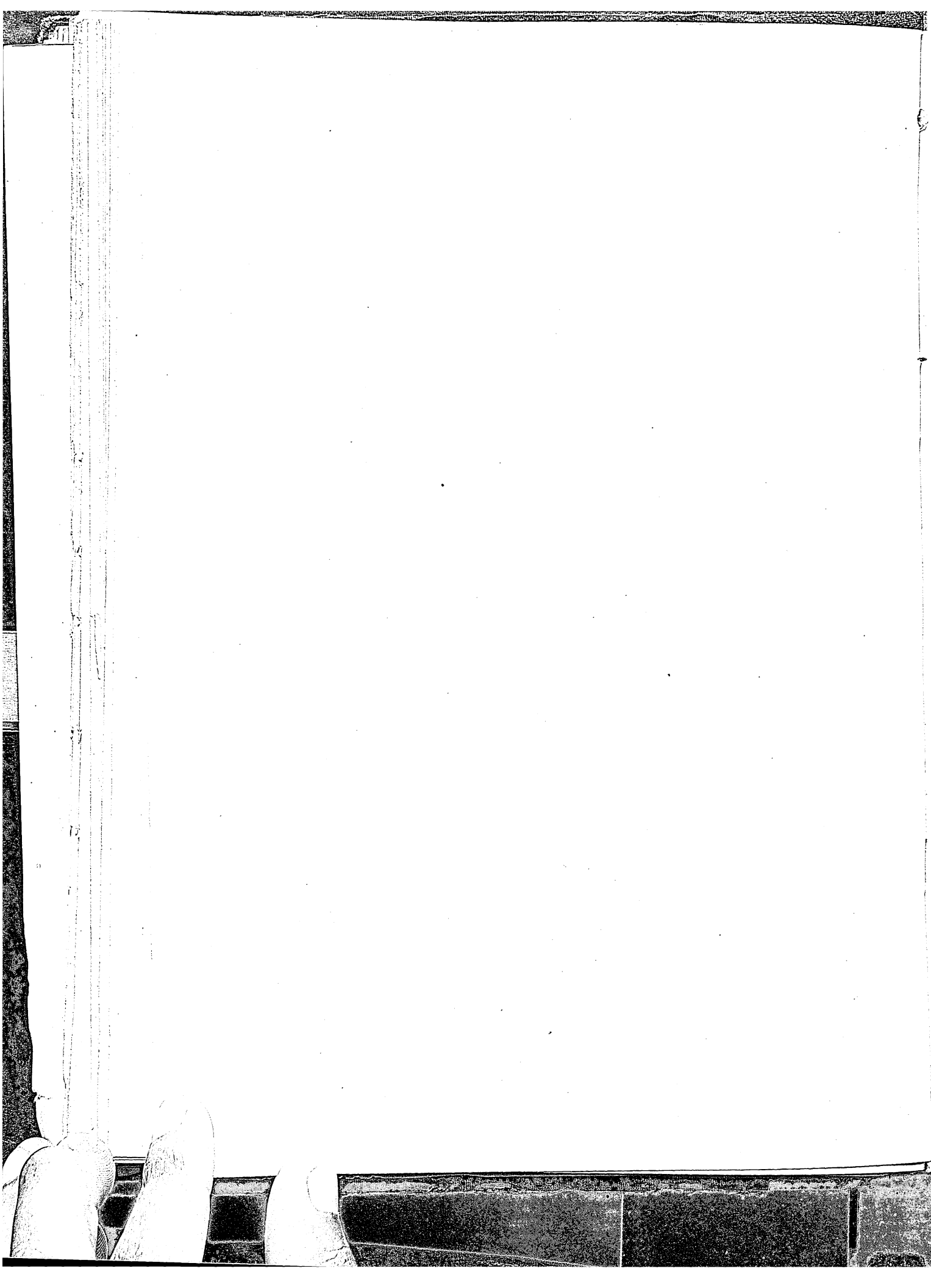

THE BIONOMICS OF *DIRHINUS PACHYCERUS* MASI (HYMENOPTERA : CHALCIDOIDEA), A PUPAL PARASITE OF MUSCOID FLIES

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Introduction

Although members of the superfamily Chalcidoidea are represented in almost every part of the globe, very little is known about their individual life-histories except for a few European species. It is well known that they are parasites or hyperparasites of a large number of insects of different orders, e.g., Coleoptera, Lepidoptera, Orthoptera, Rhynchota, Hymenoptera, etc., and attack the eggs, larvæ, pupæ and, in some cases, even the imagines of their hosts. Sharp (1901) described the life history of some of them and a useful reference on the subject has been included by Imms (1934). The life-history of different species varies widely. Considerable information in regard to the parasitic habits of different species has been obtained, but the questions connected with the possible effect of multiple infestation of a host, the disposal of its excreta, etc., have not yet been satisfactorily answered in the case of any species.

During our researches on Muscoidea we accidentally came across some pupæ of *Sarcophaga dux* var. *tuberosa* Pand. from which five specimens of Chalcidoidea, which were later identified by Dr. Ferriere of the British Museum, as *Dirhinus pachycerus* Masi, emerged. These formed the nucleus of a large stock of this parasite which was utilised for our study of its life-history and bionomics. They were propagated without much difficulty on the pupæ of the common flesh-fly, *Sarchophaga ruficornis* Wied. and the blue-bottle fly, *Chrysomyia megacephala* Fabr.

General biology

Feeding habits of the adult.—It has not been possible to ascertain with any degree of certainty whether *Dirhinus pachycerus* lives on solid or liquid food. As the food of most Hymenoptera is of a liquid nature, the peritrophic membrane being absent, it is presumed that if *Dirhinus* feeds at all, it takes liquid nourishment. The Chalcidoid, *Aphidencyrtus inquisitor* How. (Encyrtidæ), parasite of *Macrosiphum cornelli*, makes a

puncture with the ovipositor after mounting upon the back of its host, and feeds on the droplet extruded (Griswold, 1926). Since Griswold failed to find any difference in longevity between an unfed and a fed individual, it would appear that the tissue juice of its host does not form the principal dietary of the parasite.

According to Balfour Browne (1922) the female *Melittobia acasta* Walk. feeds upon the blood of its host which it obtains by puncturing with the ovipositor. When some *Dirhinus* specimens were left in association with a large variety of food of vegetable and animal origin, they were never found actually feeding nor did they betray any evidence of being attracted to a particular kind of food. However, the presence of food in their alimentary canals found on dissection, proves that they had been feeding.

Pairing.—Pairing takes place readily even in a wide-mouthed test-tube, and both males and females are sexually mature on emergence. The male plays the aggressive part, chases the female and mounts on its back. The female is thus unable to move. The act of copulation lasts from 5 to 10 minutes. One female after another is successively courted and the same female may also be copulated with more than once.

Types of reproduction.—Parthenogenesis is common in Chalcids when it may be associated with a scarcity of males (*Aphelinus sp.*, Imms, 1916). From laboratory observations it was evident that both normal sexual and parthenogenetic types of reproduction occurred in *D. pachycerus*; the offspring in the former case were males and in the latter, females. In all, 35 insects were allowed to reproduce parthenogenetically and 13 biparentally.

The observations of Graham-Smith (1919) in regard to the sex ratio in *Melittobia acasta* Walk. are of considerable interest in this connection. While the offspring derived from fertilised females included both sexes, the females predominating, virgin felmales gave birth to males only. Similarly the offspring of unfertilised females of *Nasonia brevicornis* Ashmead. according to Johnston and Tiegs (1921), were entirely males.

Oviposition.—*D. pachycerus* shows a decided preference in the choice of its hosts and in the site for oviposition. Puparia of *Stomoxys calcitrans* Linn. and *Drosophila melanogaster* are always neglected, while *Musca inferior* Stein, *M. vicina* Macq, *M. nebulo* Fabr., *Sarcophaga ruficornis* Wied, *S. dux* Thoms., and *Chrysomyia megacephala* Fabr. may be attacked in the laboratory (Roy & Siddons, 1939). Froggatt (1915) recorded *Nasonia brevicornis* parasitising pupæ of several species of blow-flies in Australia. Graham-Smith (1916) bred *Alysia manducator* Panz.

from puparia of *Calliphora, Lucilia* and some other Muscids, and *Melittobia acasta* Walk. from a large variety of blow-fly puparia.

Howard & Fiske (1912) reported that *Melittobia acasta* Walk. attacked several different kinds of fly puparia as well as hymenopterous cocoons. Froggatt and McCarthy (1914), Johnston and Bancroft (1920) and Johnston and Tiegs (1921) mentioned a large number of blow-flies as hosts of *Nasonia brevicornis.*

It is remarkable that the host specificity of Chalcids infecting fly puparia is not strictly restricted and it is presumed that the size of the host pupa, in relation to that of the pre-imaginal stages of the parasite, acts as the dominating factor in the selection of the proper host for ovipositing.

Froggatt (1915) has given a detailed description of the behaviour of female *Nasonia brevicornis* during oviposition which agrees with most of our observations which are described below.

The most curious feature about egg-laying is the selection of the site for oviposition best adapted to the growth of the offspring. After crawling for some time on its host (a Muscoid puparium in this case), and from time to time palpating the surface of the puparium with its antennæ, the most suitable place is located ; the anterior end of the puparium being more commonly selected than its posterior end. Out of a batch of 50 pupæ, which were all parasitised, eggs were laid in the posterior half of the puparium in ten only. Thus eggs are commonly deposited on the dorsal surface of the growing fly or in the lateral recess between the head and the thorax. Other sites are also chosen but less frequently.

It is surprising that though eggs are not always deposited in a way that their long axis corresponds with that of the host, nevertheless the larva assumes a position in which its head end is always directed anteriorly.

As soon as the desired site has been explored, the female stops motionless and a pair of pads, each lying just posterior to the ovipositor, is extruded. The puparium is tightly pressed by these pads. The ovipositor is now extended and quickly thrust into the puparium. As soon as the ovipositor has been introduced, the pads are relaxed and disappear from view. These pads are only visible at the time of oviposition.

The process of oviposition is of long duration and is sometimes extended to half an hour ; it is never less than 10 minutes. Only one egg is inserted at each oviposition. The introduction of the ovipositor followed by the apparent ' act of egg-laying ' may or may not be followed by oviposition. The eggs in the ovarian tubes do not mature simultaneously

and, therefore, during 24 hours many eggs cannot be laid. However, one female was able to parasitise 92 out of 100 puparia exposed for this purpose during the course of a fortnight.

Several observers (Marchal, 1909; Howard, 1910; Froggatt, 1915; Imms, 1916; Griswold, 1926; Balfour Browne, 1922) have referred to the curious habit of the female of licking the juice issuing from the puncture made by the ovipositor. Although it has been suggested that the female imbibes the fluid for its own nourishment, this has not yet been satisfactorily proved. However, the female *Dirhinus* immediately after the egg has been laid and the ovipositor retracted, turns towards the spot where the puncture was made and applies its mouth to it, perhaps with the object of closing the puncture with its saliva.

We have carefully observed that when a connection is established between the interior of the pupa and the outside air at any stage in the life of a pupa through a hole, however minute, it causes not only the destruction of the pupa but of the parasite as well. Graham-Smith (1916) made similar observations and reported that very rarely living Chalcid larvæ were found in puparia with pin-holes. It is, therefore, necessary that the opening in the cuticle of the pupa caused by the ovipositor must be closed and this is perhaps effected when the female applies its mouth to the injured spot.

Life-history and description of immature stages

The Egg

The egg is white or creamy-white in colour and elongate in shape. It measures 0.6 to 0.7 mm. in length and 0.14 mm. in breadth. The eggs of parasitic Hymenoptera may be either stalked or elliptical (Richardson, 1913; Imms, 1918). *Dirhinus pachycerus* comes under the latter category. Its anterior end is narrower than the posterior. The chorion is smooth, unlike that of *Pachyneuron* sp., which is more or less scaly (Haviland, 1922). The duration of the egg stage is roughly 2 days.

The Larva

The newly emerged larva (Figs. 1 & 2) is of minute size and is always found to lie near the site of the puncture made by the ovipositor. But as in later stages it is always found lying with its long axis in a line with that of the pupa, it is probable that it is capable of changing its place with a view to occupying a more convenient position where it can find sufficient space for its growth.

The larva lies in a shallow depression directly on the fly pupa to which it is loosely applied and becomes quickly dislodged as soon as the

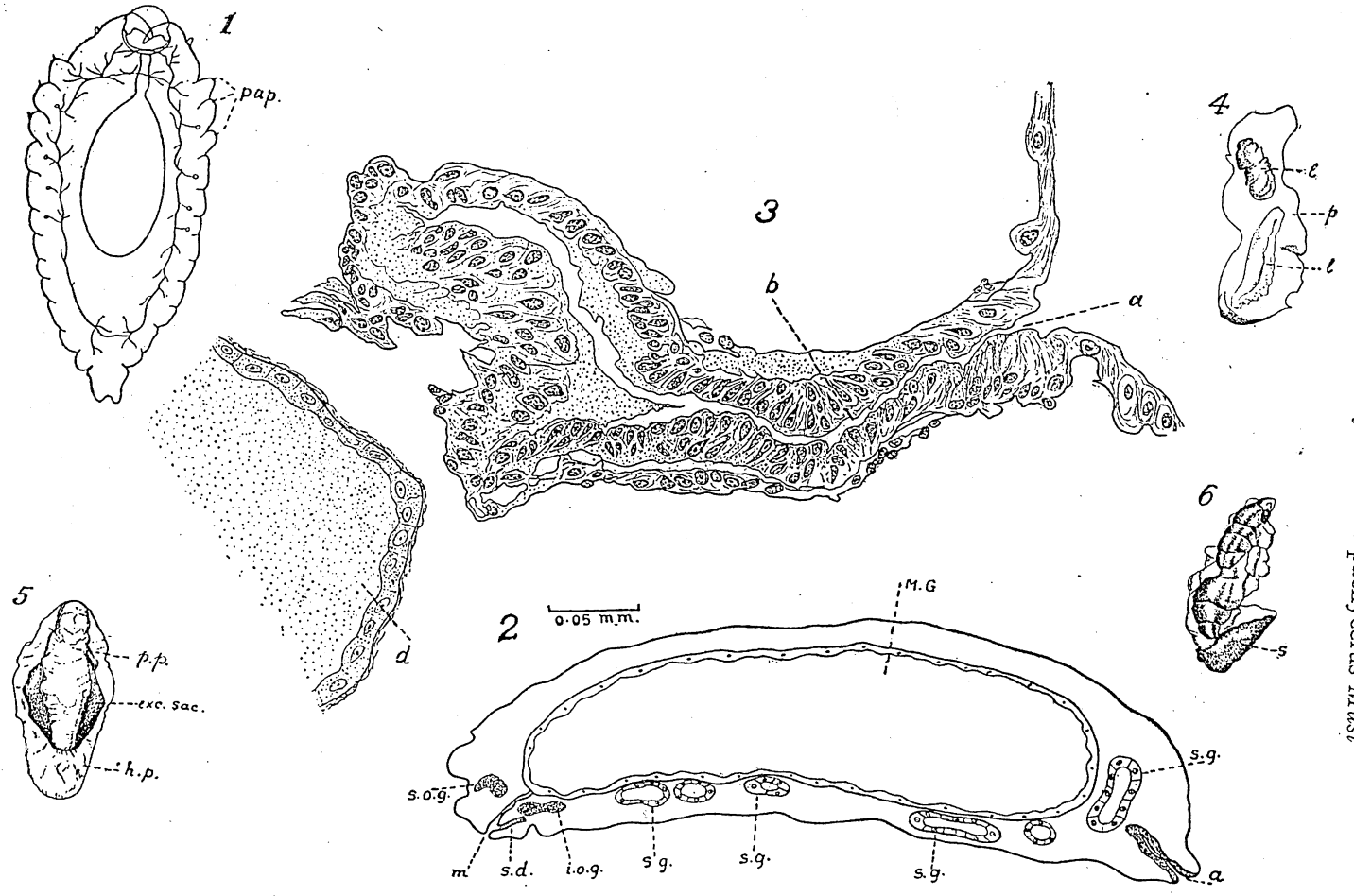

FIG. 1. First stage larva. *pap.*, thoracic papillæ.

FIG. 2. Longitudinal section of larva. *a.*, anus; *i.o.g.*, sub-œsophageal ganglion. *m.*, mouth; *m.g.*, mid-gut; *sd.*, common duct of the salivary glands; *s.g.*, salivary gland; *s.o.g.*, supra-œsophageal ganglion.

FIG. 3. Longitudinal section showing development of proctenteron by proliferation from the proctodœum. *a.*, anus; *b.*, lumen of proctenteron; *d.*, mid-gut.

FIG. 4. Multiple infestation. *fy.*, fly pupa; *l.*, mummified larvæ.

FIGS. 5-6. Showing the excretory sac. *abd.*, tip of abdomen of parasite pupa; *exc. sac* and *s.*, excretory sac; *h.p.*, host pupa.

puparium is opened. Its ventral surface, especially the mouth, is closely applied to the substance of its host. The larva lies practically motionless and its presence can only be detected by a slight movement of its cephalic extremity as soon as the over-lying cuticle of the puparium is removed. When placed in salt solution, the usual movements such as protrusion and retraction, slight twisting motion, and peristalsis are evident.

The cuticle of the young larva is thin and owing to its transparency permits an examination of some of the internal anatomy when the larva is placed in salt solution. In addition to the cephalic segment, thirteen segments of the body, composed of three thoracic and ten abdominal segments, can be clearly distinguished. Anteriorly two protuberances from the cephalic segment, which represent the future antennæ, are visible. The mouth is provided with two triangular mandibles. The thoracic segments are broader than the abdominal segments and laterally each thoracic segment is provided with a pair of minute hair-like papillæ. (Fig. 1, *pap.*). These are only visible during the early larval stage, and possibly are equivalent to the sensory organs of dipterous larvæ (Keilin, 1915).

The larvæ of *D. pachycerus* differ from those of *Dirhinus sarcophagæ* Froggatt, a parasite of blow- and flesh-flies, in the absence of jaws in the third instar of the latter. The structure of the head is also different (Johnston and Tiegs, 1921).

Although the sac-like stomach which occupies nearly the whole of the body cavity of the larva is visible from outside, the general anatomy can only be studied satisfactorily in sections (Figs. 1-3). The general arrangement of the alimentary canal closely resembles that described by Newport (1855), Imms (1916), Haviland (1920) and Mohamed (1938) in other parasitic Hymenoptera. We have not, however, been able to detect the existence of the malpighian tubules and we believe they are absent in this species. In sections the salivary glands appear as elongated organs and are relatively large in proportion to the size of the larva (Fig. 2, *s.g.*).

The development of the proctenteron in *D. pachycerus* takes place by proliferation of epithelial cells which gradually extends from the proctodoeum forwards towards the stomach (Fig. 3.) The canal of the proctenteron (*b*) near the anus (*a*) appears quite early but is joined to the stomach (*d*) at the time when the prepupal stage is reached. The development of the hind gut in *Dirhinus* sp., therefore, closely resembles that of *Lygocerus* sp. (Haviland, 1922).

In *Spalangia muscidarum* Richardson, the proctenteron appears as a tenuous cord of cells without a lumen and terminates in a small anal opening

on the ventral surface of the last segment which later in the " tracheate " larval stage is differentiated into ileum, colon and rectum, the ileum ending blindly (Richardson, 1913). Newport (1855) has described a similar method of development of the hind intestine in the larva of *Monodontomerus nitidus*. In *Brachymeria femorata* Panz., on the other hand, the canal of the hind intestine exists from the beginning though it is blind at both ends (Mohamed, 1938).

The size of the larva varies considerably; while a young larva measures 0.6 mm. in length, a mature larva is about 7.0 mm. long.

In *Spalangia muscidarum* the tracheæ appear quite late in the life of the larva, whereas in *Dirhinus* the tracheal system is present from the beginning. The first-stage larva shows only four pairs of spiracles (Figs. 1 & 9), one on the mesothorax and one on each of the first three abdominal segments. After the first moult has taken place, five additional pairs appear, one on the meta-thorax and the others on the fourth to the seventh abdominal segments. This description closely resembles the accounts given by Imms (1918) in *Blastothrix britannica* Gir. and by Balfour Browne (1922) in *Melittobia acasta*.

Duration of larval stage and ecdyses.—During summer in Calcutta the larval life extends over a period of 7 to 10 days and during winter 18 to 20 days. The number of ecdyses undergone by the larva is difficult to determine. The only indication that ecdyses take place is afforded by the increase in the number of spiracles from four to nine in course of a week. The structure of the jaws do not afford any indication of ecdysis as was recognized by Johnston and Tiegs (1921) in the three instars of the larvæ of *Nasonia brevicornis*.

Feeding habits of the larva.—It is held that the larva is a fluid feeder and the mandibles are used for the purpose of anchoring itself to its host. That the contents of the mesenteron consists of microscopic particles of solids is amply borne out in sectional preparations. We have not, however, been able to obtain any evidence that the contents of the mesenteron are derived from blood, as has been described by Richardson (1913). The larva of *Spalangia muscidarum* Richardson, according to him, consumes the blood plasma and its cellular contents. As we have also observed definite signs of nibbling of the host at the site where the mouth is applied, we are of opinion that this is effected by the mandibles.

Excretion.—While following the life-history of *D. pachycerus*, the question arose as to the exact method of the disposal of the excreta. The presence of a large blind mesenteron naturally suggests that until the proctenteron is established, the mesenteron is made use of for storing all its waste products, in addition to performing its normal function of digestion. The proctenteron joins the mesenteron and is able to function only

towards the last stage of its larval life. With the establishment of this canal, the larva enters the prepupal stage ("semipupa" of Packard). As soon as the hind gut becomes patent, the larva is able to discharge all its accumulated excreta through the anus into a sac formed by the larval skin. In the beginning the sac is very small and appears as a small dark brown irregular mass situated at the posterior extremity of the larva. The enlargement of the sac proceeds gradually with the growth of the insect (Figs. 5-7).

The pupa rests loosely on the conical depression of the excretory sac formed by the larval skin and the anus of the insect is closely applied to an opening situated at the apex of the cone so that the excreta can freely pass into the sac. The excretory matter is not, however, discharged all at once as soon as the proctenteron joins with the mesenteron. At the time the adult parasite escapes from the puparium, the excretory sac formed by the larval skin appears considerably shrivelled, suggesting that the discharge of the excretory products takes place during the prepupal and early pupal stages. The contents of the sac are much darker and more dense than the light brown colour of the fluid contents of the mesenteron. This method of disposal of the excretory products of the larva has, so far as we are aware, not been previously reported in any of the parasitic Hymenoptera.

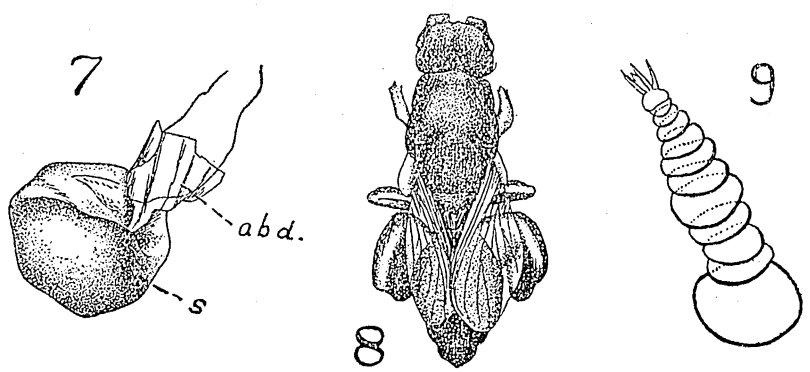

Fig. 7. The excretory sac (*s*).
Fig. 8. Adult *Dirhinus pachycerus*.
Fig. 9. Spiracle of larva.

Prepupa and pupa

The transition from the late larval to the prepupal stage is marked by the appearance of the rudiments of legs. This stage lasts for about two days. It is only during the pupal stage that wing buds make their appearance. This stage lasts for nearly 12 days in summer and from 25 to 30 days in winter.

The whole life-cycle occupies about 20 days in summer and 45 to 60 days during winter.

Multiple infestation (Fig. 4)

According to Imms (1916), multiple attacks on a single host are not followed by oviposition in every instance, as in many cases, he detected the presence of only one egg in a single host. Although the introduction of the ovipositor is not necessarily followed by the deposition of an egg, we have nevertheless noticed the presence of as many as six eggs and four larvæ lying irregularly distributed on a single pupa. The effect of multiple infestation in relation to the parasite and the host was studied after dissection of parasitised puparia from day to day. Under such conditions either all the puparia died or only one survived.

When more than one larva was present in a puparium, the one occupying a position between the head and thorax of the fly was usually noticed to have outgrown others and in course of time those placed in less favourable positions had succumbed. Such instances, where only one growing larva was found and others had died, were fairly common. The death of these larvæ under such circumstances could not be ascribed to a shortage of food, if we take into consideration the fact that the dead specimens represented larvæ of different ages and most of them had not attained even one fourth the size of a mature larva.

Fabre (1886), as cited by Sharp (1901), during his investigations on the life-history *Leucospis gigas*, found that the primary larva which greatly differed from its secondary larva in habits and external characters preyed upon supernumerary eggs and larvæ. As we have often found eggs and young larvæ lying in close proximity to a growing larva, we are of opinion that the larva of *D. pachycerus* is not predacious.

EFFECT OF PARASITISM ON THE HOST

All accumulated evidence points to a highly deleterious effect being exercised by the parasite on the host, the loss of the vital sap of the latter being possibly responsible for its death. Gatenby (1918) is of the opinion that parasites eat up everything but what is absolutely necessary to keep their *vache a lait* living. When parasites have used their unfortunate host long enough to enable them to grow sufficiently, they kill their host by eating up its vitals.

In spite of the fact that *D. pachycerus* grows at the expense of its host, it is doubtful if the latter actually suffers death from deprivation of its vital sap. Day to day examination of the host, a pupa of *Sarcophaga ruficornis* in this case, revealed that it can thrive for some time, but eventually dies and later becomes converted into a shrivelled mass, when the

general configuration of the insect can hardly be made out. The length of the pupal life of *S. ruficornis* lasts for 4-6 days, and if the infested pupa is examined within a reasonable time, say ten days after infestation, evidence of the gradual growth of the pupa at places which are not directly affected by the growing parasite is clearly visible. Thus the general outline of the fly, e.g., head, thorax and abdomen with the bristles, can be made out clearly. This indicates that the little tearing of the parts by the mandibles of the parasite does not materially affect the growth of the host and that the food available in a pupa is more than sufficient for the nourishment of a single parasite. The death of the host, according to our observations, is due partly, to the actual pressure exerted by the parasite on the host, and partly to the loss of its vital fluids.

It is remarkable that it is only during the early or mid period in the development of the Muscoid pupa that infestation normally takes place, as all attempts to infest them during later stages were without success, probably owing to the reluctance of the female to lay eggs in puparia which had already reached an advanced stage of development. We have never found any evidence of eggs being laid under such conditions.

Practical utility

There appears to be some scope for utilising *Dirhinus* in the biological control of those Muscoidæ which are readily parasitised by them. If the host is easily accessible to the Chalcid, parasitisation will inevitably ensue and the degree of parasitisation will depend on the numerical ratio between the two. Even when the hosts are superficially covered by loose sand or earth, the parasites may burrow in the sand, and can under such circumstances also effectively perform their mission, which they fail to do if the pupæ are placed inside loosely packed garbage or under a deep layer of sand. As a rule Chalcids prefer to visit places like dry sand and loose earth.

Graham-Smith (1916) adduced evidence which reveals the extraordinary destruction wrought by the English sheep-fly parasite, *Alysia manducator*. The same observer has also come across instances of Chalcid infection in fly pupæ buried in the ground. Froggatt (1919) regarded *Dirhinus sarcophagæ* as capable of digging well beneath the soil in search of *Sarcophaga* pupæ.

From laboratory observations we believe that *D. pachycerus* should prove useful in controlling the increase of the common flies of this country, but the behaviour of this parasite in the field must be first worked out, as only then it would be possible to assess the check it could exercise over the breeding of the common flies.

Summary

(1) The parasite, *Dirhinus pachycerus*, is capable of successfully attacking a fairly large number of fly hosts.

(2) The presence of food in the alimentary canal indicates that the adult parasite takes nourishment though it has never been actually observed to feed.

(3) Reproduction can take place in two ways : by parthenogenesis, by normal sexual reproduction. Parthenogenetically produced individuals are always males and sexually produced ones are always females.

(4) The parasite possesses remarkable natural instinct in the selection of its host and also in the choice of the site for oviposition.

(5) Only one egg is extruded at each attack.

(6) The life cycle of the parasite extends for about 20 days in summer and from 45 to 60 days in winter.

(7) The food of the larva is mostly liquid. The first stage larva is not predaceous on supernumerary eggs and larvæ.

(8) The alimentary canal at a later stage becomes a continuous tube and is able to discharge at the prepupal stage the contents of the mesenteron which are received in a sac formed by the larval skin.

(9) Multiple infestation of a single host often takes place. Under such conditions either one larva or none at all will thrive owing to the available space being insufficient for more than one larva.

(10) The scope of employing these parasites for the biological control of some common fly has been briefly indicated.

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SHORT NOTES AND EXHIBITS

A fresh cycle of the desert locust in India

It is of interest to record that the desert locust, *Schistocerca gregaria* Forsk., has this year assumed gregarious phase after remaining in the solitary phase since 1931. The desert areas of Rajputana and Sind received a fairly good rainfall during last summer (1940) after having experienced dry conditions for the past several years. Up till June 1940, the population of the locust in this area was extremely low but after the rainfall, when the wild vegetation gave forth abundant foliage, the locust started breeding rapidly, specially in the Tharparkar district of Sind and in the Bikaner and Jaisalmer States of Rajputana. Towards the end of August the population was very high as compared with the same time last year. During September the hoppers showed signs of gregarious phase and the locusts which developed from them were also of swarming phase. These locusts formed swarms and left their original homes in the second half of October and penetrated into the Punjab and Baluchistan. Some swarms migrated towards the east and invaded the south eastern districts of the Punjab, Delhi Province and the adjoining districts of the United Provinces. It is feared that this represents the beginning of a new locust cycle.

New Delhi, 30. x. 40. HEM SINGH PRUTHI

Pantala flavescens Fabr.

On the 24th August, 1940, at about 5 P.M., a swarm of some hundreds of dragon-flies (*Pantala flavescens* Fabr.) was seen near the southwest corner of the estate of the Imperial Agricultural Research Institute, New Delhi, about 25 feet above ground level. The dragon-flies continued to fly towards east for about an hour and the swarm was practically of the same intensity throughout this period.

It is suspected that the species had emerged at some distance from the Institute in large numbers on the aforesaid date and the insects were probably migrating to some other locality in the east. There is, however, no marshy swamp or weedy tank (where dragon-flies usually breed) near the locality which could give rise to the swarm.

P. flavescens is known to be very common throughout India, Ceylon and Burma to as far north as Tibet and is, therefore, circumtropical and sub-tropical in distribution. It has been observed to emerge as adult towards the end of September and commence a migratory flight which may last till November. The swarm under reference was noted just a month earlier than the time recorded for it by Fraser in the *Fauna of British India, Odonata*. 3 : 415-416 1936.

New Delhi, 23. x. 40. B. B. BOSE

Myllocerus lætivirens Marshall as a pest of plum and almond

The weevil, *Myllocerus lætivirens* Marshall has been known to be fairly common on cotton plants in Delhi (Ahmad, *Indian J. Ent.*, 1 (1 & 2) : 109). In June and July, 1940, however, I found it doing serious damage to certain varieties of plum and almond trees in the orchard of the Entomologcal Section, Agricultural Research Institute, New Delhi.

The top leaves were eaten away to begin with, but later, the lower leaves on the branches were also completely eaten. In some cases the principal veins were only left intact. It is interesting to record that only the adult weevils had migrated to plum and almond trees and there were no immature stages on the plants.

New Delhi, 26. vii. 40. GHULAM ULLAH

Food plants of *Creontiades pallidifer* Walker

The Capsid, *Creontiades pallidifer* Walk. breeds in Delhi throughout the year on a large variety of crops: on lucerne throughout the year; on brinjal, safflower, potato, pea, berseem and hollyhock from January to April; on melon and *Hibiscus esculentus* from April to June; on sorghum, *Luffa ægyptiaca*, bottlegourd, sannhemp, groundnut and cowpea from July to September; on *Cajanus cajan* and maize in October and on cabbage, cauliflower, knol-kohl, turnip, radish, lucerne, and hollyhock from November to December. During autumn it occasionally becomes very serious on maize and *juar* (*Sorghum vulgare*) sucking the ear heads.

It is feared that it may become a serious pest of any of the above mentioned crops specially maize, *Sorghum vulgare* and lucerne.

New Delhi, 26. vii. 40. GHULAM ULLAH

The Tachanid, *Erycia nymphalidephaga* Bar., parasite of *Papilio demoleus* Linn.

A very heavy infestation of citrus plants in the newly laid orchard of the Entomology Section of the Imperial Agricultural Research Institute, New Delhi, by *Papilio pemoleus* Linn. developed during August and September, 1940. The plants are about 60 in number and over two years old. Before the laying out of the orchard, there were not more than a dozen stray plants of citrus near the Institute which covers an area of about 2 sq. miles and the occurrence of the lemonbutterfly was not marked enough to be noticeable.

In rearing about 70 caterpillars of *demoleus*, about 15% were found to be parasitised by the Tachanid, *Erycia nymphalidephaga* Bar. The average larval period of the host caterpillars was observed to be 12-17 days and this period was unaffected by their parasitisation. A parasitised larva became yellowish brown as compared to the perfect green healthy larva. This change was at once noticeable after the 3rd instar, i.e., the ' last black moult '. The growth of the parasitised larva was stunted and some of the larva died in spite of abundant food supply and healthy surroundings. These dead caterpillars were left over for considerable time to see whether any parasitic maggots would emerge, but none did. On dissecting, a few of these dead caterpillars, the maggots were found to be very young and also a few were dead. Possibly they leave the host only on attaining a definite stage of development.

After about 5-7 days of pupation 5- 9 maggots of creamish colour emerged out through a puncture made somewhere about the middle of the lateral of the pupa. The colour of the parasitised pupa was dull brown instead of the green of the healthy pupa.

The size of the maggots depends upon the number emerging out of one pupa. The minimum number of maggots out of one pupa was 5 and their

average length was about 0.9 cm.; while the maximum number was 9, their average length being about 0.6 cm. only. The difference in size, can perhaps be explained by the limited food available for the maggots inside the pupa. The maggots after about two hours started to turn brownish and a little later changed into pupæ of dark chocolate colour.

The flies emerged in 10-15 days after the maggots came out of the host pupæ. It is noteworthy that some of the parasitised pupæ are yet lying dormant though flies have emerged out of their companion-pupæ. These dormant pupæ are certainly not dead.

In the Imperial Pusa Collection, there are a number of specimens of this Tachanid, reared for the first time in 1919 from *P. demoleus* at Pusa. There has, however, been no record of this parasite since then.

New Delhi, 1. xi. 40. C. N. MODAWAL

A new host of *Microbracon lefroyi* Dudgeon and Gough

This insect is a common ectoparasite of the larvæ of *Earias* spp. and *Platyedra gossypiella* Saund. In 1939, however, it was found for the first time parasitising the "leaf-miner" of *untchara* (*Heliotropium supinum*). This fact was again ascertained during July 1940 when the parasitisation in nature extended to 22.5%. The new host has yet to be identified.

Lyallpur, 25. x. 40. KHAN A. RAHMAN

Two lepidopterous pests of *motia* (Jasmin)

Floral-bud borer. Of 260 unopened flowers of *motia* examined during September, 1940, 30.4% were found damaged by an unidentified capterpillar which is green in colour. The larva bores into the bud and may damage two or more flowers which do not open. Pupation takes place in a light silken cocoon usually outside the flower from which dusty brown moths emerge in about six days.

Leaf eating caterpillar. Leaves of *motia* plants were badly eaten by some green caterpillars (yet unidentified) during September, 1940. Pupation takes place on leaves and cocoon is formed.

Lyallpur, 25. x. 40. K. N. TREHAN

Some more hosts of the cotton white fly

The cotton white fly, *Bemisia gossypiperda* Misra and Lamba, is well known as a polyphagous species, its host list comprising about 50 different plants. An examination of the wild and cultivated plants growing on the estate of the Punjab Agricultural College, Lyallpur, during 1939-40 revealed five new food plants of the white fly. These are the common pea (*Pisum sativum*, L.), *alsi* (*Linum usitatissimum*, L.), *senji* (*Melilotus parviflora*, Desf.), *maina* (*Medicago denticulata*, Willd.) and *dhania* (*Coriandrum sativum*, L.).

Lyallpur, 25. x. 40. KHAN A. RAHMAN

Seasonal activity of *Athalia proxima* Klug

The mustard sawfly, *Athalia proxima* Klug., has been hitherto believed to be active in the Punjab only during winter. It will be interesting to record

that towards the close of the last rainy season its larvæ were found in large numbers damaging cauliflower plants in a nursery at the Agricultural College Farm, Lyallpur.

Lyallpur, 25. x. 40. S. A. SHAH

Notes on the mite, *Tenuipalpus* sp.

These mites are found feeding in large numbers on the upper surface of the leaves of crab apple during summer, the maximum damage being done from April to June. The infested parts of leaves which are small in the beginning gradually extend in size, and turn brown. Ultimately such leaves dry and fall off. Eggs are laid singly along the veins. During November and December, the adults migrate to branches and hibernate underneath the buds of the previous year's growth. As many as seven of these reddish brown adults may be seen under each bud.

Lyallpur, 25. x. 40. A. N. SAPRA

Pachymerus gonagra F. as a store pest

This species, hitherto recorded as a serious pest of forest trees and shrubs, has been recently observed for the first time as a pest of stored products, damaging pods of *Tamarindus indica* at Lyallpur. Eggs are laid singly and are glued to the pods or the seeds if naked. The young larvæ bore into the seed and pass the entire larval stage in it. The full grown larva spins a tough white cocoon partly inside the seed and partly protruding outside the pod. Occasionally the cocoons may be spun on the pods. The adults emerge by cutting a circular hole in the cocoon. The insect breeds actively during summer, but hibernates during winter probably in the adult as well as in the larval stage.

Lyallpur, 25. x. 40. GURCHARAN SINGH SOHI

Plant hosts of two important aphids, *Myzus persicæ* (Sulzer) and *Aphis maidis* (Fitch) at Pusa

The aphids, *Myzus persicæ* (Sulzer) and *Aphis maidis* (Fitch) are known to be important transmitters of several virus diseases of plants in England and U. S. A. The former species is known to be associated with no less than twenty-one viruses, chiefly of the aic group, found in spinach, cucumber, mustard, cabbage, turnip, sugar-beet, potato, tobacco, tomato, *datura*, capsicum, etc. *A. maidis* is a vector of mosaic of sugarcane and yellow-dwarf of onions (*Allium* sp.) in U. S. A. In view of the fact that these species are concerned in the transmission of so many viruses, a study of their food plants was made at Pusa during 1936-39.

1. *Myzus persicæ* was observed at Pusa on the following twenty-one host plants during November-February :—Cruciferæ : *Brassica juncea* (*rai, sarson*), *B. oleracea cauliflora* (cauliflower), *B. rana* (turnip), *B. campestris* (mustard), *Raphanus sativus* (radish). Malvacæ : *Althea rosea* (hollyhock). Leguminosæ : *Dalbergia sissu*. Rosacæ : *Prunus persicæ* (peach), *Prunus communis* (plum). Compositæ : *Ageratum conyzoides*. Orobancacæ : *Orobanche* sp. Solanacæ : *Withania somnifera, datura, stramonium* (datura), *Solanum nigrum** (black night shade), *S. tuberosum* (potato), *Lycopersicum esculentum*

(tomato), *Nicotiana tabacum* (tobacco), *N. plumbaginifolia** (wild tobacco), *N. rustica** (hooka tobacco), *N. glauca** and *N. glutinosa**.

It may be added that leaf-curl diseases of the virus type have often been noticed at Pusa and in other parts of North Bihar on the majority of the plants enumerated above, and it is likely that *Myzus persicae* is capable of transmitting at least some of these diseases, but so far there is no experimental evidence in support of this view.

2. *Aphis maidis* (Fitch) has been noted at Pusa on *Avena sativa* (oats) during January-February; *Hordeum vulgara* (barley) during January-March; *Andro-sorghum* (= *Sorghum vulgare*) during June-July; *Triticum vulgare, T. sativa*, (wheat) during January-February; and *Zea mays* (maize) during June-August. As this species, which is reported to be chiefly responsible for the transmission of mosaic virus of sugarcane in the United States of America, West Indies, etc., also exists on some important graminaceous crops in North Bihar where the cultivation of sugarcane is rapidly increasing, its presence should be of great interest to those who are interested in the cultivation of this crop.

Pusa, 10. xi. 40. C. K. SAMUEL

New host records for *Elasmus albomaculatus* Gahn and *E. johnstoni* Ferr.

On January 30th, 1935, two Chalcid larvae were observed feeding on a larva of *Holcocera pulverea* Meyr. *kusum* x *khair* lac (*Laccifer lacca* Kerr) at Namkum. One parasitic larva was in the 1st instar: it was observed to moult three times and was full-fed on the 5th day. It passed the meconium on the 6th day and pupated 2 days later, on 7th February, 1935. The pupal period was 11 days and the adult, a male, emerged on 18th February, 1935. The second larva gave rise to a female adult on 19th February, 1935. The pair were caged for oviposition with lac sticks infected with both *Eublemma amabilis* Moore and *H. pulverea* larvæ but failed to lay eggs. The male lived for 32 days and the female for 4 days only.

The adults were identified at the Imperial Institute of Entomology as *Elasmus albomaculatus* Gahn. This is the first and only time *E. albomaculatus* has been observed as a parasite of *H. pulverea*.

Elasmus johnstoni, Ferr. was bred at Namkum in August, 1938 as a hyperparasite of an unidentified species of *Apanteles* parasitic on the larva of *Sylepta derogata* Fabr., feeding on *Hibiscus esculentus* at Namkum.

Namkum, Ranchi, 10. vii. 40. P. M. GLOVER

Anopheline mosquitoes on the estate of the Agricultural College, Coimbatore

The following note on the anopheline mosquitoes found on the estate of the Agricultural College and Research Institute, Coimbatore, is based on field observations and systematic study of the mosquitoes in the entomological collection of the Institute. The nomenclature adopted in this note is the one followed by Christophers in "*The Fauna of British India, Diptera*, 4, 1933, Culicidae, Anophelini.

Contrary to a belief long held, the mosquito fauna of Coimbatore has been found to include as many as 29 different species and a fair number of these had been bred out from larvae or pupæ collected on the estate of the Institute.

Puri (Health Bulletin, 1936 No. 17, 2nd. ed.) has recorded 20 different species of *Anopheles* from the Coimbatore District. Some of these are known to be very important carriers of malaria in certain parts of India. In spite of the presence of these malarial species, the disease is rare in this locality and even the few cases recorded are believed to be imported ; this is evidently due to the fact that ideal condition for the mosquitoes to transmit the disease are absent.

Six, out of 20 species of anophelene mosquitoes recorded by Puri, are represented in the entomological collection of the Institute at Coimbatore. The most common and the one that is found all the year round is *Anopheles sub-pictus* Grassi, which has been found to breed in cement drains, rain water tanks, bungalow compounds, moat pits, etc., on the estate. *A. culicifacies* Giles, another species that has been reared from rain water tanks in bungalows, has been observed in February-March and from September-November and is found in sufficiently large numbers in houses and cattle sheds though it escapes notice because of its culex-like posture ; it is said to be a very important malaria carrier in India. Specimens of *A. jeyporiensis* James., *A. vagus*, Dontz., and *A. annularis* Vander Wulp., have been caught in mosquito traps set up in bungalows but have not been reared from larvæ. *A. barbirostris* Vander Wulp., a rather wild species, has also been collected in the adult stage.

Coimbatore, 16. x. 40. T. V. SUBRAMANIAM.

Dacus ferrugineus var. *dorsalis* Hendl. in South India

Munro (*Indian J. Ent.*, 1939 **1** : 101-105), who examined a large series of specimens from north-west India, apparently containing both *Dacus ferrugineus* Fb. and its variety *dorsalis* Hendl., concluded that colour differences between the specimens of the species and those of the variety were not significant and that the Indian specimens were distinguishable from the specimens of *dorsalis* from Formosa by the blackness of the fore tibiæ. The author suggested that the Formosan specimens alone should be referred to this variety.

Observations on *Dacus ferrugineus*, breeding in wild species of Solanum and other fruits in the Nilgiri hills, South India, indicate that *dorsalis* variety occurs in this part of the country and infests fruits of *Solanum auriculatum*. The variety completes its life-cycle in 18-24 days, the duration of the various stages being : egg, 2-3 days ; maggot, 8-9 days and pupa 8-12 days. The flies could be kept alive under laboratory conditions for 19-54 days. Presumably this variety does not infest mango, guava, plum, pear and quince growing in these hills.

The variety *incisus* was also observed breeding in fruits of *S. auriculatum*. The fruits of *S. robustum* and *S. sisymbriifolium* were free from fruit-fly attack.

Coimbatore, 5. xi. 40. M. C. CHERIAN and C. V. SUNDARAM

RECENT RESEARCH

Use of selenium as an insecticide

During the last decade quite a number of experiments have been performed to test the effects of introducing selenium into plant tissues with a view to controlling insect pests. In some cases the tests have been made on plants growing in water or soil cultures to which selenium, usually as sodium selenate, has been added ; in others, observations have been made on plants growing in soils known to contain minute quantities of selenium (about 2 or 3 parts per million). In both cases, it has been noticed that plants whose foliage were able to accumulate 10 to 40 (or more) parts per million of selenium, have been remarkably free from mites, aphids and similar other insects.

Selenium was discovered in 1817 and is found in many parts of the world, including India. Its use as an insecticide has been based upon the fact that it is extremely poisonous to animals but very much less so to plants. In American agriculture, however, it has become important more as the toxic agent responsible for a serious disease of livestock, through feeding on selenium-containing fodder, than as an insecticide. In India selenium has not been used as an insecticide so far though the ill effects consequent upon feeding on plants containing this substance does not appear to be altogether unknown in the country.

Hurd-Karrer and Poos (*Science*, **84** (2176) : 252, 1936) reported that plants growing in solution cultures or soils containing very small amounts of selenium were not attacked by the aphid, *Rhapalosiphum prunifoliæ* (Fitch), and that concentrations even lower than 10 p.p.m. in the soil would prevent serious infestation. Mason and Phillis (*Emp. Cott. Grg. Rev.*, **14** (4) : 308-9, 1937) carried out some experiments with ' Sea Island ' cotton plants grown in sand cultures, containing 5, 10, 20 and 50 p.p.m. of sodium selenate respectively and found that the populations of aphids, cotton stainers (nymphs) and pink bollworms were reduced in proportion to the dosage of selenium administered to the plants. The workers also observed that ' selenised ' cotton plants were not repellent to pink bollworms, since oviposition occurred on both ' selenised ' and normal plants equally well.

Recently Neiswander and Morris (*J. econ. Ent.*, **33** (3) : 517-23, 1940) have studied the effects of introducing selenium, in the form of sodium selenate, into the plant through water cultures in which tomato, rose, carnation and black chrysanthemum plants were growing. The plants were infested artificially either with the red spider, *Tetranychus telarius* (L.) or the aphid, *Macrosiphoniella sanborni* (Gillette), and statistical differences in the population data were

determined by the method of analysis of variance. The results of these studies showed that when the selenium concentration of foliage approached 90 to 100 p.p.m., the red spider practically disappeared and similar results were obtained in the case of the aphid with a selenium content of 45 p.p.m. only. Even with half the proportions of selenium in the leaf tissues, appreciable reductions in the aphid and red spider populations were noticed.

On the other hand, Trelease, Helen and Trelease (*Amer. J. Bot.*, **24** (7) : 448-51, 1937) observed that the Bruchid, *Acanthoscelides fraterculus* (Horn), and the seed Chalcid, *Bruchophagus mexicanus* (Ashmead) could consume seeds of *Astragalus bisulcatus* containing 1475 p.p.m. of selenium and complete their life cycles in them without any ill effects ; in other words, on a ' diet containing about seventy times the concentration of selenium which is known to be lethal within a few weeks to rats, cattle, pigs, sheep and horses.' These observations would appear to show that not all insects are susceptible to selenium poisoning but whether this immunity is specific or is to be associated with any other grouping of insects is not clearly known.

Selenium has been used as poison in some proprietory mixtures of which one is *Selocide*, containing 8% potassium-ammonium-seleno-sulphide, for which it has been claimed that it would kill all stages of the red spider, including the eggs. Indeed the use of selenium in insecticides grew so common some years ago that Nelson, Hurd-Karrer and Robinson (*Science*, **78** (2015) : 124, 1933) sounded a note of warning against this practice. The authors stated that quantities as small as 1 p.p.m. may allow growth and maturation of the plants with no visible symptoms of injury but when the grain or straw from such plants was fed to experimental animals (rats and guinea pigs) pronounced toxicosis characterised by retardation in growth resulted, leading to death in a few weeks. Clearly this is an aspect of the problem which will have to be seriously considered if and when insecticidal trials with selenium are made in India. Some workers, including Neiswander and Morris, are, however, of the opinion that with the same care as is usually taken in handling potassium cyanide, selenium may be quite a practical thing to use in routine entomological work, but its use may perhaps best be restricted to the control of pests of ornamental plants where the amount of selenium required would be small and the products of the plants would not be used for edible purposes. K.B.L.

Chemotropic response of males to the sexual smell emitted by females

The phenomenon of attraction of males to the sexual scent emitted by females is recorded for several nocturnal Lepidoptera. Götz has recently investigated (*Zeit. Augew. Ent.*, **26** : 143-164, 1939) the phenomenon in the grapevine leaf rollers, *Clysia ambiguella* and *Polychrosis botrana*.

Reviewing previous work the author states that the effective range of the so called sexual scent is in some cases astonishingly great. Thus the males

of *Philosomia cynthia* are attracted from a distance of $1\frac{1}{2}$ miles and those of *Porthesia dispar* from about $2\frac{1}{2}$ miles to their respective females. Such long-range effect of sexual scent has led to the belief that attraction is not due to the perception of smell but due to the influence of some unknown rays. This is however contradicted by the observation that males do not respond to females kept close to them in airtight containers. Further, the failure of this reaction when the antennæ of the male which carry receptor organs are removed or covered over with a coating of varnish, points out that the phenomenon depends on smell perception of an extraordinarily fine order. These smelling substances are beyond the human power of perception. For example, cantharidine which in spite of its apparent lack of smell exerts, even when present in very minute traces, a very high degree of attraction to certain insects.

The influence of sex-scents seems to be specific. The males react only to the females of their own species; to females of other species they remain indifferent. Further, only sexually mature females emit the smell.

Experiments conducted by Götz with *Clysia ambiguella* and *Polychrosis botrana* have shown that only sexually mature virgin females are capable of attracting their males. Simultaneous presence of the female and male is not necessary. It is enough if the female has been at the spot within some specified time. The sexual scent in these two species has no effect on the males of the other species. The intensity of attraction is directly proportional to the quantity of the sex-scent; three females produce greater excitement and attract males from a longer distance than does one female.

Trials carried out in the field to test the practical utility of these experiments showed that the attraction exercised by the females was much more than any hitherto known chemical attractant used for them. The range of attraction was at least up to 20 metres radius for *Polychrosis botrana* and 25 metres for *Clysia ambiguella*, which could be further increased by increasing the number of females. The number of males caught in the traps varied considerably from day to day and probably depended on several factors, such as weather, age of female, condition of males, etc. White traps captured two to three times the number of *Clysia* males as compared to black ones, which signifies positive phototropic response of the moth during flight.

As the males appear in nature before the females, great majority of them can be captured before they accomplish copulation. Field trials indicate great possibility of utilising the sexual scent for control purposes. T. A.

Aphid migration

Problems concerning fluctuations in insect numbers due to climate and biotic factors have recently received particular attention from economic entomologists. Such fluctuations are directly affected by the conditions determining

the flight of insects. Various mechanical insect traps have been devised to obtain data on the flight of insects in the field.

Williams and Milne insect trap as modified by Davis (*Bull. ent. Res.*, **26** : 553, 1935) had been in operation in North Wales for five consecutive summers from the end of May up to the 15th August, for trapping aphids. The results of trappings have been analysed by Thomas and Vevai (*Ann. appl. Biol.*, **27**(3) : 393-405, 1940) and correlated with the meteorological conditions of the locality. It is found that the number of aphids trapped depends on the number of alatæ available. Large numbers of alatæ would appear, if there are (a) large fluctuations in daily temperature, (at least 12°F) ; (*b*) a large percentage of dry sunny days tending towards drought conditions ; and (c) low humidities.

Under field conditions large flights of aphids took place when (*a*) the wind was from the north-east, (*b*) the wind velocity was very low (generally 0-2 m.p.h.), (*c*) the maximum temperature was above 75°F, and (*d*) the relative humidity was below 80%. Wind velocity was the most important factor limiting flight, as very few aphids were trapped when the wind velocity was above 5 m.p.h.

The conditions defined above generally prevailed during May and June in the years 1935, 1936 and 1939 ; consequently there were large migrations and more aphids were trapped. During May and June of 1937 and 1938, the temperature did not rise above 70°F and the relative humidity was abnormally high (never below 80%), with the result that only 12 specimens were trapped from 1st June to 15th July in 1938.

During the course of five seasons seventy six species were recorded. The number of specimens of each species trapped every year has also been noted. G.U.

Some new factors governing host selection by parasites

Lloyd (*Proc. roy. Soc.*, B., **128** : 451-454, 1940) has made a laboratory study of the oviposition behaviour and incidence of superparasitism and multiparasitism of three primary parasites of the diamond black moth, *Plutella maculipennis* Curt. The three parasites are *Diadromus collaris* Gravenhorst and *Angitia cerophaga* Gravenhorst (Ichneumonidæ) and *Apanteles plutella* Kurdjnmor (Braconidæ). All the three species are endoparasites. *Diadromus* attacks the prepupæ and pupæ. *Angitia* and *Apanteles* parasitise the larvæ. Lloyd's experimental studies besides throwing light on the important aspect of parasite introductions, are a contribution to our knowledge of insect behaviour. It was assumed by entomologists that superparasitism or multiparasitism resulted because the female parasite was not gifted with a prescience to discriminate between parasitised and non-parasitised individuals. Lloyd has shown that *D. collaris*, *A. cerophaga* and *A. plutella* possess this discriminating faculty in varying degrees, and has thus corroborated the findings of some very recent workers on the same problem. *Diadromus* always preferred unparasitised hosts to parasitized ones and superparasitism occurred only in hosts containing recently

deposited eggs. *Cerophaga* rejected larvæ containing eggs, or first and second instar grubs of its own species. *A. plutella* avoided hosts containing immature stages of its own species. This faculty to discriminate between parasitised and non-parasitised hosts is not to be compared to intra-specific cases only, i.e., where the female parasite is able to distinguish immature stages of its own species. It is clearly exhibited even in cases where the host larvæ contain immature stages of quite a different genera. Thus *Diadromus* rejected pupæ containing advanced stages of *Cerophaga*. Multiparasitism occurred when the host larvæ contained immature stages of *Angitia* but oviposition in these conditions was restricted. *Cerophaga* avoided host larvæ containing eggs of *plutellæ*, while *plutellæ* itself rejected hosts containing immature stages of *cerophaga*.

These findings are important because they provisionally support the view taken by the earlier entomologists that great benefit might result by the introduction of all the primary parasites of a pest. The validity of this hypothesis was questioned by later workers who emphasized the harm that might result by competition between the different primary parasites of the same host. Lloyd's experiment on *Diadromus*, *Angitia* and *Apanteles*, however prove that there is a basic tendency among these parasites to avoid hosts containing immature stages of their own or another species. E.S.N.

A plume moth (*Oxyptilus regulus* Meyr.) on grape in S. India

In an interesting and well illustrated paper (Bull. ent. Res., 30 (4) : 471-474, 1940) Subramaniam has given a brief but comprehensive account of the incidence, bionomics and economic importance of *Oxyptilus regulus* Meyrick, which appears to be the first record of it as a pest—at least as far as peninsular India is concerned. Though we have plume moths noted on red gram (*Cajanus cajan*), bottle gourd, brinjal, etc., in different parts of India none of them has assumed the status of an important crop pest—except perhaps the red gram moth, *Exelastis atomosa*, W. From the brief account of the life history described, the insect appears to be a typical berry borer. In this respect it is found to be quite different from the grape plume moth, *Oxyptilus periscelidactylus* F. of the eastern regions of the U. S. A., though both belong to the same genus. This latter insect is reported to damage grape vines by its larva attacking the foliage by webbing the terminal leaves and feeding inside the fold. The American species is different in color from *O. regulus*. Results of some preliminary trials with Pyrethrum dusting, which appear to be promising in checking the pest, are also added. It will be interesting and useful to watch the progress of this new pest and the status it might eventually come to occupy. T.V.R.

NEW BOOKS & MONOGRAPHS

Adaptive coloration in animals. By Hugh B. Cott, with an introduction by Julian Huxley. Pp. xxxii + 508, 49 pls., 1 Frontispiece, Illus. London, Methuen and Co. Ltd., 1940. Price £2 net.

The chemistry and toxicology of insecticides. By Harold H. Shepard. Pp. 383. Minneapolis, Minnesota: Burgess Publishing Co., 1939. Price $4.00.

Guide to the study of the evolution of the wings of insects. By James Chester Bradley. Second edition. Pp. 60, 25 text-figures, 83 plates of wings. Daw. Illston and Co., Ithaca, N. Y., 1939. Price (paper bound) $1.25.

In this edition the author has added twenty pages, fifteen figures to the text, and 16 plates.

A synopsis of the Hemiptera of America, north of Mexico. By J. R. de la Torre-Bueno. *Entomologica Americana,* **19 :** 141-310, 1939 (For sale by the Brooklyn Entomological Society, 28 Club Way, Hartsdale, N. Y.) Price $3.50.

The bark and timber beetles of North America, north of Mexico. By W. J. Chamberlin. Pp. vi + 513, 321 figures, 5 plates. Cornvallis, Oregon : Oregon State College Cooperative Association, 1939. Price $6.50.

A valuable addition to the literature of North American Scolytoidea, the book is roughly divided into two parts, biological and taxonomic. The former deals with such aspects as fossil forms, habits, distribution, economic importance, types of larval and adult galleries, seasonal history, inter-relationships with fungi ; the latter gives original descriptions of species with keys to families, tribes, genera and species.

Fourth supplement to the Leng catalogue of Coleoptera of America, north of Mexico. By Richard E. Blackwelder. Pp. 146 ; 1939. (For sale by John D. Sherman, Jr., 132 Primrose Ave., Mount Vernon, N. Y.) Price $6.00.

This supplement contains chiefly a list of species described during 1933-1938 period, together with synonyms, changes of names and corrections.

The scientific principles of plant protection : with special reference to chemical control. By Hubert Martin. Third edition. Pp. x+385. London : Edward Arnold and Co., 1940. Price 22s. 6d.

British water beetles. By F. Balfour-Browne. Vol. I. Pp. xx+376, 5 plates. (Ray Society, Vol. 127 for 1939), London : Bernard Quaritch Ltd., : 1940. Price 25s.

The New Systematics. By Julian Huxley. 8vo, Pp. viii+583. London : Oxford University Press, 1940. Price 21s.

Monograph of the South American weevils of the genus Conotrachelus. By K. Fredler. Pp. 315. London : British Museum (Natural History), 1940. Price 15s.

The biology and control of wireworms : Review of literatures. By C. A. Thomas. *Bull. Pennsylvania State College* No. 392. Pp. 90. State College, Pennsylvania, 1940.

The bionomics of entomophagous insects, Part II. By W. V. Balduf. Pp. 384. New York : John Swift & Co., 1939. Price $ 5.00.

Animal behaviour : Impulse, Intelligence, Instinct. By J. A. Loeser. London : Macmillan & Co., 1940. Price 10s. 6d.

A survey of insecticide materials of vegetable origin. Edited by H. J. Holman. Pp. vi + 155. London : Imperial Institute, 1940. Price 3s. 6d.

Insect transmission of plant diseases. By J. G. Leach. Pp. xviii+615, 238 fig. London : McGraw-Hill Publishing Co., 1940. Price $ 6.00.

Biology in the making. By Emily Eveleth Snyder. Pp. xii + 539. London : McGraw-Hill Publishing Co., 1940. Price 18s.

Instructions for collectors, No. 4A : Insects. Compiled by John Smart, with the assistance of other members of the staff of the Department of Entomology. Pp. vi + 164. London : British Museum (Natural History), 1940. Price 1s. 6d.

Insect pests of the Punjab

Dr. Khan A. Rahman has recently published [*Punjab Agric. Coll. Mag.* (Insect pest number), 1940, **6** (5-7) : 1-98] a useful account of the insects which commonly infest various farm and fruit crops in the Punjab. The publication contains descriptions of the life-history, nature of damage and methods of control of injurious species followed by accounts of the use and methods of preparation of some insecticides and spraying, dusting and similar other machines that have been in use in the province. The descriptions are throughout illustrated and it is obvious that, but for the limitations imposed by cost, the drawings should have appeared greatly improved. Students and field entomologists, who are called upon to help in the control of insect pests in the Punjab, should find the publication handy for ready reference.

NEWS AND ANNOUNCEMENTS

The programme of the Entomological Section of the Indian Science Congress to be held at Benares in January 1941 includes discussions on the following subjects :—

1. Position of systematics in Applied Zoology and Entomology.
2. Biological control of insect pests—its possibilities and limitations.

The schemes for the survey of the San Jose scale and for the ' clean-up ' campaign against the spotted bollworms of cotton in the Punjab were closed on the 31st March and 30th April 1940, respectively.

A new entomological station of the Department of Agriculture, Punjab, has been started at Kotgarh (Simla hills) for the study of insect pests of fruit trees.

Dr. K. D. Baweja, M. Sc. (Punjab), Ph. D. (London), has been appointed Assistant Locust Entomologist, and Dr. S. Pradhan, M. Sc., D. Sc. (Luck.), as Assistant Entomologist (Scheme for study of insect populations) at the Imperial Agricultural Research Institute.

With the extension of the term of Mr. M. Afzal Husain as Vice-Chancellor of the University of the Punjab, Dr. Khan A. Rahman, B. Sc. (Edin.), Ph, D. (Cantab.) will continue to officiate as Entolomogist to Government, Punjab.

Mr. P. M. Glover, Entomologist, Indian Lac Research Institute, Namkum-Ranchi, has resigned his membership of the Executive Council of the Entomological Society, having been called up for military duty.

We regret to record the following deaths :—

(i) Sir Thomas Hudson Beare (born June 30, 1859 at Adelaide : died June 10, 1940 at Edinburgh). A distinguished engineer, who held the regius professorship of Engineering at the University of Edinburgh since 1901. Sir Thomas was also an enthusiastic amateur entomologist, being chiefly interested in the systematics of Coleoptera. One of the Vice-presidents of the Royal Entomological Society of London in 1934 and author of a systematic monograph on British beetles.

(ii) Edward Payson Van Duzee (1861-1940). Founder and editor of the *Pan-Pacific Entomologist* during the first fourteen years of its existence. A great authority on American Jassidæ.

(iii) Dr. Willis Stanley Blatchley (born 1859 : died May 28, 1940). Author of monographs on Coleoptera, Orthoptera and Heteroptera of north-eastern America.

PROCEEDINGS OF
THE ENTOMOLOGICAL SOCIETY OF INDIA
(Up to November 1940.)

DELHI BRANCH—NEW DELHI

31st July

Exhibits

Myllocerus laetivirens Mask., as a pest of plum—GHULAM ULLAH

Wohlfahrtia nuba Wied., parasite of *Poecilocerus pictus* Fabr.—H. L. BHATIA

The water beetle, *Eretes sticticus* Linn., an efficient predator of mosquito larvæ—SHER KHAN

Pupation habits of the citrus leaf miner, *Phyllocnistis citrella* Staint.—B. B. BOSE

Communications

The nest of *Vespa orientalis* Linn.—K. B. LAL

Research work on the spotted and pink bollworms of cotton in the Deccan area—H. D. NANGPAL (by invitation)

Some interesting insects appearing at the break of monsoon in Delhi—MOHAN SINGH

New food plants of *Poecilocerus pictus* Fabr. among cultivated crops—MOHAN SINGH

Creontiades pallidifer Walk. (Capsidæ) as a potential pest of crops—GHULAM ULLAH

18th September

Exhibits

Common species of blister beetles in Delhi—SHER KHAN

Pantala flavescens Fabr., swarming in Delhi—B. B. BOSE

Communications

Pachydiplosis oryzae Mani and the 'silver-shoot' disease of paddy—R. K. SONTAKAY

The mode of feeding of the larva of *Dichocrocis punctiferalis* Guen.—MOHAN SINGH

12th November

Exhibits

Andrallus spinidens Fabr. (Pentatomidæ), predating on the Noctuid, *Anticarsia irrorata* Fab.—MOHAN SINGH

Shoots of *Bauhinia veriegata* damaged by the Tingid, *Bredenbachius annandalei* Dist.—GHULAM ULLAH

Leaves of *Abutilon indicum* damaged by the Chrysomelid *Chaetocnema* sp.—GHULAM ULLAH

Nest of the Vespid, *Icaria variegata* Sm.—GHULAM ULLAH

A new mealy bug, *Pseudococcus* sp. on the roots of *Saccharum ravennæ* Linn.—V. P. RAO

THE BENGAL BRANCH—CALCUTTA

8th May

General — Members discussed the question of increase in the annual subscription payable by ordinary members and resolved to make a representation on this subject to the Executive Council of the Society.

Communication — The origin and mechanism of variations in genes and chromosomes—D. P. RAICHOUDHRY

30th July

Communication — Head segmentation in insects—embryological evidence —M. L. ROONWAL (by invitation)

31st August

Communication — Malarial mosquitoes of Bengal—P. SEN (by invitation)

PUNJAB BRANCH—LYALLPUR

30th April

Exhibit — *Tenuipalpus* sp.—A. N. SAPRA

Communication — "Clean-up" operations against the spotted bollworms of cotton. II.—LADHA RAM

31st May

Exhibit — *Pachymerus gonagra* F.—GURCHARAN SINGH SOHI

Communication — *Ber* beetle—M. A. GHANI

23rd September

Exhibit — Two Lepidopterous pests of *motia*—K. N. TREHAN

Communication — Effect of temperature on the biology of khapra —GURCHARAN SINGH SOHI

BIHAR BRANCH—PUSA

27th October

Exhibits

Specimens of cane damaged by *Argyria tumidicostalis* Hamp.—R. P. SINHA

Communications

A new record and occurrence of *Argyria tumidicostalis* Hamps. in eastern Bihar.—L. N. NIGAM

Copulation amongst nymphs and between nymphs and adult bugs of *Serinetha augur* Fabr. (Coreidæ) —C. K. SAMUEL

SIND & BALUCHISTAN BRANCH—KARACHI

28th November

General

Origin of locust swarms in Rajputana during the summer of 1940—a discussion in which almost all the members of the branch as well as some from New Delhi took part.

SOUTH INDIA BRANCH—COIMBATORE

10th December

Exhibits

Trichospilus sp., a pupal parasite of *Diatræa venosata* Wlk., which is easily bred in the laboratory ; *Goniozus indicus*, a larval parasite of *Diatraea venosata* Wlk., *Scirpophaga* sp. and *Chilo zonellus* Swinh., recently described by Muesebeck under Ashmead's manuscript name—M. C. CHERIAN.

Aspidiotus sp., on *Gossypium trilobum* and *G. herknessii*, being the first record of *Aspidiotus* on cotton—V. MARGABANDHU.

Communications

Trials with 'Malariol' and 'Pyrocide 20' against mosquito larvæ—T. V. SUBRAMANIAM.

Host selection by *Spathius critolaus* Nixon, a Braconid parasite of *Pempheres affinis* Fst. in South India—P. N. KRISHNA AYYAR.

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